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ORIGINAL ARTICLES.

On a Freshwater Shale with *Viviparus* and Associated Beds from the Base of the Carboniferous Rocks in Ribblesdale, Yorkshire.

By Professor E. J. Garwood, Sc.D., F.R.S.

(PLATE XIII.)

THE specimens here described were obtained by the writer from a pocket in the surface of the Silurian Slates about 200 yards to the north of Gillet Brae, exposed during the preliminary excavation for Mr. Delany's quarry (the Horton Lime Works) in 1889. The quarry is situated on the right bank of the Ribble, opposite Horton village. The site of the exposure is now buried under tip heaps and there is little chance of further sections being exposed.

As a detailed survey of the district recently undertaken by the writer has revealed no beds of a similar character in West Yorkshire, it may be of interest to put on record the details of the section at the time it was exposed.

Description of the Section.

The deposits in question, which are of considerable interest owing to the unique faunas they contain, consisted when they were exposed in 1889, of two beds, each a few inches in thickness, occupying a slight depression in the surface of the upturned Silurian Slates.

These two beds are overlain by a thin layer of black calcareous shale, containing crushed specimens of *Cyrtina carbonaria*, which can still be seen at the base of the quarry.

This shale forms a thin layer at the base of the massive limestone of the *Nematophyllum minus* subzone, which, as a rule, forms the lowest horizon in the Carboniferous deposits on either side of the Ribble valley to the north of the Craven Faults. It will be convenient to refer to the two lower beds of the section as

the Viviparus Shale and
the Lamellibranch Limestone respectively.

The diagram (Fig. 1) gives the general succession as seen in 1889. The two beds, V and L of Fig. 1 did not form one continuous deposit, but were sharply separated from one another both by their lithological characters and by their fossil contents, the general relation between the two being evidently that of a non-sequence.

The Viviparus Shale.—This bed, which rested on the surface of the Silurian rocks, consists of a friable sandy mudstone, devoid of any appreciable calcareous constituents; it averaged about 2 inches in thickness, and was traversed by numerous irregular cracks. The fossils occur exclusively in the highest layer of the deposit. The majority of the forms are gastropods, evidently belonging to a species of *Viviparus*, but associated with these, occur numerous examples of a thin-shelled lamellibranch. The bed itself is totally different, not only from the Lamellibranch Limestone which overlies it, but from any other deposit hitherto met with in the lower Carboniferous rocks in the north of England. It has all the appearance of a sandy mud laid down in a freshwater pond on land. Under the microscope the deposit is seen to be composed of closely set alternating layers of coarse and fine material consisting of abundant sub-angular fragments of quartz embedded in a brown impalpable mud; a notable quantity of iron pyrites is also present, which frequently occurs in thin layers lying parallel to the bedding planes.

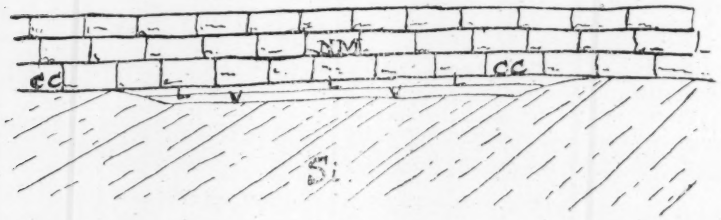


FIG. 1.—Diagram section of the base of the Carboniferous exposed in 1889, 200 yards N. of Gillet Brae. Si, Silurian; V, *Viviparus* shale; L, Lamellibranch limestone; CC, *Cyrtina carbonaria* shale; NM, *Nematophyllum minus* limestone.

The character of the jointing resembles shrinkage cracks due to desiccation rather than to movements like those to which the dip and strike joints which traverse the overlying massive limestone are probably due. The pond cannot have been of any great dimensions as the deposit does not extend back into the present floor of the quarry, where the crushed Cyrtina Shale lies directly on the Silurian floor. It is also absent from the face of the escarpment to the north and south where the main mass of the limestone with *Nematophyllum minus* overlaps on to the Silurian. Again, the shaly limestone which overlies the conglomerate in Gillet Brae, 200 yards to the south, contains no trace of this deposit. The pond may, however, have extended to the east, but again no trace of it has been found on the east side of the Ribble valley, where the base of the Carboniferous is exposed near Douk Gill and to the north of Dub Cote.

DESCRIPTION OF FAUNA.

Viviparus carbonarius sp. nov. Pl. XIII, Figs. 1 and 2

Description.—Height of largest specimen	. .	14 mm.
Height of body whorl	. . .	6·5 mm.
Body whorl to total height	. .	46 : 100
Spiral angle	. . . . .	50°
Sutural angle	. . . . .	about 100°

Shell thin, smooth, turbinate, umbilical furrow obscure. Number of whorls 4–5; whorls tumid, separated by a deep suture; sutural angle only moderately oblique. Apex blunt. Ornament consisting only of fine growth-lines becoming rugose on the body whorl. Mouth apparently sub-circular, but obscured by crushing.

The oldest British example of *Viviparus* (*Paludina*) so far recorded is *P. langtonensis* Hudleston, from the *Paludina* bed in the Chipping Norton limestone of Inferior Oolite age at Langton Bridge, where it is associated with other freshwater species and occasionally seeds of *Chara*, etc. *Viviparus carbonarius* differs from *P. langtonensis* in its relative proportions as will be seen by a comparison with the measurements and description of the Inferior Oolite species,[1] *V. carbonarius* being a distinctly blunter and more tumid form.

Carbonicola angulata, de Ryckholt. Pl. XIII, Fig. 3.

Numerous specimens of a thin-shelled lamellibranch, evidently a *Carbonicola*, and apparently referable to de Ryckholt's species *C. angulata*, occur with *Viviparus carbonarius*.[2]

Euomphalus sp.

A few crushed specimens of gastropod shells, most nearly resembling *Euomphalus*, also occur.

The only other organism met with in this bed was a crushed and fragmentary specimen of a *Pleurotomaria*, which occurred on the upper surface of the deposit and was probably introduced at the beginning of the marine submergence which followed.

The specimens of *V. carbonarius* occurred in considerable numbers and include numerous young forms, and the same was the case with the specimens of *C. angulata*. In comparing this occurrence of *Viviparus* with the oldest previously known species in the Inferior Oolite, it is interesting to note that the Horton bed is also overlain by a band containing fish remains and plants, marking in both cases the incursion of the sea to form an estuarine deposit. Outside of Britain the oldest recorded species of *Viviparus* also occurs in the Lower Oolite (Bathonian) of France. Hitherto the accepted opinion appears to have been that freshwater gastropods made their earliest appearance in Mesozoic times. Thus Professor Sollas, in his chapter

[1] Inferior Oolite Gastropoda, Mem. Pal. Soc., 1896, Pl. xliv, figs. 1*a* and 1*b*, p. 488.

[2] See Hind, Monogr. Carbonicola, etc., 1894–6, pl. xi, figs. 3–5, p. 75.

on "The Origin of Freshwater Fauna" in *The Age of the Earth*, remarks "*Paludina* traces its descent from the ancient stem of the Trochids and Turbonids which, as already mentioned, are found in Cambrian sediments. It may possibly have originated in Devonian lakes, but its absence from Carboniferous and Permian rocks would suggest a later date." The precise age of the Viviparus Shale at Horton is not easy to determine. It was evidently deposited in a depression on the land surface which was being eroded during Devonian times, and before that surface was submerged under the Carboniferous sea. From this point of view it might be claimed as being of Devonian age. The question is in reality a far-reaching one. During the submergence which ushers in a new geological period, certain areas may remain for a very long time above the level of the sea in which the marine deposits belonging to the new period are being laid down in the neighbourhood. The conditions on the surviving land surfaces will, however, represent a continuation of those which prevailed during the preceding continental period, and the question arises—at what moment does the land surface cease to belong to the earlier period and form part of the new period? In the case before us a considerable area of country in the north of England remained above the sea while lower tracts of land were being submerged in the south-west province and elsewhere under the Tournaisian sea. In the Horton district, the old Devonian land surface does not appear to have been inundated until the time when the *Cyrtina carbonaria* and *N. minus* beds were being laid down. It is therefore impossible to determine the exact period when the Viviparus Shale was deposited on the continental surface, and there is no means of deciding whether this freshwater deposit should be classed as Devonian or Carboniferous.

The Lamellibranch Limestone.—The Lamellibranch Limestone, overlying the Viviparus Shale, is also a thin bed, an inch or two in thickness, but differs essentially from the bed below as regards its petrographical character and its fossil contents. The two beds appear to have been formed under very different physical conditions. The Viviparus Shale, as stated above, represents apparently a freshwater deposit formed on the surface of the old Devonian continent, while the overlying Lamellibranch Limestone was evidently a shallow-water deposit laid down in a strait or estuary connected with the advancing Carboniferous sea.

The rock consists of a black crystalline limestone, which in thin sections is seen to be made up of shell fragments, together with a few tests of Endothyra and occasional remains of bryozoa. The matrix is composed of fine-grained granular calcite in which are embedded a few small angular grains of quartz. The character of the deposit is therefore very different from that of the underlying Viviparus Shale, which is devoid of calcite and organic remains. The fossils are well preserved and consist chiefly of large well-grown lamellibranchs which include the following forms:—

Aviculopecten dissimilis Flem.
Lithodomus carbonarius Hind.
Myalina verneuilli M'Coy.
Myalina peralata de Kon.
Pseudamusium ellipticum (Phill.).

In addition to these a few examples of other forms occur :—

A large crushed cup coral, cf. *Zaphrentis enniskilleni* Ed. and H.
Lingula squamiformis Phill.
Orbiculoidea nitida Phill.
Fenestella sp.
Conularia quadricarinata Sby.
Euomphalus sp.
Psephodus cf. *magnus* Ag., and also a few plant remains referable to *Pteridorachis*.

This assemblage of forms, though undoubtedly of Lower Carboniferous age, cannot be assigned to any definite horizon in the north of England succession, but as the bed underlies the *Cyrtina carbonaria* sub-zone which forms the floor of the quarry, it cannot well be newer than the horizon of the gastropod beds of Westmorland or S_1 of the Bristol district, and may be of even earlier date. It will be noted that none of these species occurs in the *Michelinia* zone, which represents the lowest horizon met with in the district.

The only locality in the North-West Province where the writer has noted lamellibranchs at a low horizon is at Pinksey Gill, Ravenstonedale[1] below the Shap conglomerate. Here we find casts of *Aviculopecten*, *Lithodomus lingualia* and *Myalina*, associated with species of *Lingula*, *Orbiculoidea*, *Psephodus* and *Pteridorachis*. The species of the lamellibranchs here, however, are different and on account of their occurrence below the Shap Conglomerate and for other reasons, it is probable that the Pinksey beds are of older date than the Lamellibranch bed at Horton.

From this description it is evident that the section formerly exposed at Horton is of considerable interest, as it carries back the earliest known occurrence of *Viviparus* to Lower Carboniferous times at least and possibly even to the Devonian period.

EXPLANATION OF PLATE XIII.

Fossils from the base of the Carboniferous Limestone, Horton-in-Ribblesdale, Yorkshire.

Figs. 1–3 from the Viviparus Shale.
Figs. 4–7 from the Lamellibranch Limestone.

FIG.
1. *Viviparus carbonarius* sp. nov.
2. *Viviparus carbonarius*. Group of crushed specimens, slightly enlarged.
3. *Carbonicola angulata* (de Ryckholt).
4. *Myalina peralata* de Kon.
5. *Myalina verneuilli* (M'Coy.).
6. *Aviculopecten dissimilis* Fleming.
7. *Pseudamusium ellipticum* (Phill.).

[1] *Q.J.G.S.*, vol. lxviii, 1912, p. 496.

On the Pliocene Flora of Transcaucasia.

By J. W. Palibin (Batoum).

It is well known that the existing flora of Western Caucasia is of great interest from the point of view of the origin of the floras of Europe and Asia, as in it have survived to this day numerous types of plants which were widely spread over the Northern Hemisphere during Tertiary times. The Palæontological history of the Tertiary Flora of the Caucasus is very meagre.[1] The Pliocene Flora of the Caucasus is discussed by me in my work [2] on the presence of the leaves of the recent Caucasus beech-tree (*Fagus orientalis* Lipsky) and some other species of deciduous trees and shrubs in the Pliocene beds, the so-called "Aktschagyl Series", of the Elisapethpol province. It is worthy of remark that the wood was found in seams interstratified with beds rich in well-preserved Pliocene shells, which could be determined with certainty. It was proved that in the southern Caucasus there existed in Pliocene times the same species of beech as at present.

Some little time ago I learned that petrified wood occurred on the boundary of the Caucasian Provinces Batoum and Tiflis, near the Godersky summit. This place, known as the "Fossil Wood", contains impressions of ferns, palms and various other flowering plants. It is situated on the eastern side of the watershed between the Caspian and the Black Sea, on the line between Borjom and Batoum. The river bed of Koblian-Tchai, in which the deposit occurs, is situated 50 kilometres from the Black Sea coast. The Godersky summit, where the fossil wood has been found, is situated near the source of the Adjara River, on the western slopes of the great Armenian plateau, where streams run on one side to the Black Sea, on the other to the Caspian. The way to the Godersky summit leads from Ahalzich down to the Benary Station, where the Ahalzich-Batoum road begins. The road to the summit lies in the broad valley of the Koblian-Tchai, through the large village of Adigun: some 8 kilometres further the River Dzundza falls into the Koblian, and the Ahalzich-Batoum road, following the bed of the little river,

[1] Professor N. Kuznetzoff mentions the following sources in his work on the "Principles of the Division of the Caucasus into Phytogeographical Provinces" (chapter on Fossil Floras of the Caucasus): *Mém. Acad. Imp. Sci. St. Petersburg*, Sér. III, Phys. Math., cl., vol. xxiv, 20, 1, 1919 (Russian):—

1. J. Felix, *Zeitsch. deutsch. Geol. Ges.*, 1894, p. 79.
2. J. W. Palibin, *Bull. Com. Géol. St. Pétersb.*, 1902, No. 55, p. 205.
3. J. W. Palibin, *Verhandl. Russ. Min. Ges.*, Bd. xliii, Lief. 1, 1906.
4. V. H. Engelhardt, *Beitr. Palaeont. Geol. Oester.-Ungarns und des Orients*, Bd. xv, Heft ii and iii, 1903.
5. F. Unger, *Sitzb. Akad. Wiss. Wien.*, bd. xi, 1853.

In addition to these sources reference may be made to H. Abich's paper on Miocene plants from Russian Armenia: *Mém. Acad. Imp. St. Pétersb.*, vol. viii (Sér. iv), 1859; also to W. Bogacev, *Ann. Géol. et Miner. de la Russie*, vol. xv, livr. 8–9, 1913, and *Mém. du Mus. du Caucase*, Sér A, No. 2, 1915, p. 69.

[2] *Bull. Musée du Caucase*, t. viii, livr. 3–4, 1915, p. 267 (Russian).

runs parallel to the left ridge of this valley. In the middle of its course the valley broadens somewhat, but further on it becomes narrower and cuts through the western slope of the Godersky summit, by a rather narrow canyon. The upper part of the valley is formed by two ravines where the River Dzundza has its source. The Godersky summit has an altitude of 6,500 feet; on the eastern side the slope is very gentle, but its western slopes descend steeply into the valley of the Adjariszhali. The valley of the River Dzundza throughout its whole length cuts through a region of volcanic strata, the lowest of which are andesite lavas. Higher up above the village of Uthisuban the valley becomes much narrower and the bed of the river cuts into volcanic deposits, for the most part Andesite tuffs mixed with lava of a light grey colour. The artificial cornice of the road afforded an opportunity of ascertaining not only the stratigraphical features of these volcanic beds, but it also led to the discovery of rich collections of fossil plants. On examining the tuffs lying above the line of the road one realizes that the strata are not uniform in their formation. The tuffs are almost horizontal, dipping slightly to the west, with an inclination of some of the strata towards the south; they are intersected by many cuttings. The rock is far from being homogeneous; it consists of rather irregular strata made up of light grey and light violet-grey tuffs cemented together with light yellow clay.

The engineer, A. P. Guerassimoff, who kindly investigated the rocks, found they were fine-grained, rather soft, and comparatively loosely cemented, containing small black carbonized remains of plants with volcanic glass of irregular form and of light yellow colour. The clay cementing the tuffs is sometimes covered with oxide of iron. Small fragments of minerals are common; the mineral most frequently met with is a colourless, quite fresh labradorite; felspar is also not uncommon; prismatic crystals and small fragments of colourless or light green augite are more rarely met with. Pyroxene not infrequently contains incrustations of magnetite. Another characteristic mineral is the brown hornblende. Lastly, one sometimes finds occasional sections of pleochroic hypersthene. There are many small crystals of magnetite and, in some places, little heaps of discoloured volcanic glass and fragments of andesite lava. The distribution of coloured remains in the rock is irregular; in one sample hornblende is predominant, in another pyroxene. These tuffs are cemented with clay where they have fallen, and there are no traces of any disintegration of the rock. It is to be presumed, therefore, that their fall was the cause of the burning of the forest.

Trunks are abundant, also fragments of trees and branches of different kinds. In some places, for instance, one may see immense stumps, one of them standing *in situ* with wide spreading roots and with a diameter of 1 meter 30 centimetres. Higher up in the tuffs one can distinguish the remains of the upper part of this trunk. The tree is a dicotyledon. Wood is common throughout the tuffs,

lying in all directions and in different stages of preservation, some pieces looking like opal, while others form soft carbonized masses. All the trunks which occur here, both solitary and in groups, are embedded in the rock.

A superficial study of the material collected has led to the recognition of ten to twelve species of different trees. The dominant forest species were broad-leaved dicotyledons; the largest trunks are certainly of this type. Conifers also occur, some with their structure very well preserved; among these are represented *Pityoxylon*, *Cupressinoxylon*, and *Araucarioxylon*.

It is clear, judging by the impressions of plants, that the flora was different from that which exists to-day. The impressions are mostly those of evergreen plants, bushes, gramineous plants and ferns, which represent the remains of a tropical and sub-tropical flora buried in lava cinders. Among this material are immense cordiform leaves, no doubt allied to Paulownia, the modern representatives of which occur in Japan and China. Similar Paulownia leaves have been recorded by Laurent from the lower Pliocene volcanic deposits of central France; our fossils differ from the western European forms chiefly in the truncated (not rounded) lamina of the leaves; the younger specimens exhibit marked dentations. In view of this difference it is appropriate to regard the Caucasus form as distinct from the European type and to name it *Paulownia caucasica*. Several species of laurel are common, and leaves of similar type are widely distributed in rocks of this age in southern Europe. These forms have disappeared from Europe, except *Laurus nobilis*, which occurs in Mediterranean countries and in the Pontish province of Caucasia. The laurels are represented by *Laurus primigaria* Ung., a type characteristic of the lower and middle Miocene of Europe, and related to the existing *Laurus canariensis* Sm., also *Laurus Lalagas* Ung. Camphor-trees are also represented by many specimens of *Cinnamomum Scheuchzeri* Heer, a species which was spread over Europe in the Miocene period and occurs in the Sarmat beds of northern Caucasus.[1] Lastly, *Oreodaphne Heeri* Gaudin occupies an important place in this flora; it is very characteristic of European Pliocene floras and is abundant in the Upper Miocene.

The fig-tree family is represented by two forms, *Ficus populina* Heer, very characteristic of the Miocene of Europe, Western Siberia, and the region of the Aral Sea, and *Ficus multinervis* Heer, characteristic of the middle Miocene of Europe. The beech has not been found here. Oaks are represented by *Quercus furcinervis* (Rosm.) Ung., a characteristic form in the Pliocene and Miocene of Europe and South Russia. The Anonaceae are represented by *Anona elliptica* Ung., a form recorded from the Miocene of southern Europe. The Heath family is represented by *Andromeda protogaea* Ung., widely spread in Miocene and Oligocene Europe. The

[1] J. Palibin, *Verhandl. K. Russ. Min. Ges.*, Bd. xliii, Lief. i, 1906.

Eleagnaceae have also been found here; e.g. *Eleagnus acuminata* Web., a common form in upper Miocene formations of Europe.

Among species with deciduous leaves occurs *Rhamnus rectinervis* Heer, a type known only in the lower Miocene of Switzerland and Germany. There is also a new form of the genus Berchemia, very like the upper Miocene form *Berchemia multinervis* A.Br., found in Switzerland. This species I propose to name *B. Winogradowi* sp. nov. Among the willows found in this locality may be mentioned *Salix media* Heer, a willow recorded from the upper Miocene of Switzerland and some other places in Europe. It is possible that this willow with *Andromeda protogaea* Ung. composed the underwood of the original forest.

The rush *Phragmites oeningensis* A.Br., grew among grass plants in damp forest situations; this is a kind of rush widely spread in the Miocene of Europe and north Asiatic countries. Some Gramineae, sedges, and various ferns are also met with. There was also found a fragment of the fan palm of the Chamaerops type not yet definitely determinated.[1] Among ferns it has been possible to recognize the following: *Aspidium Meyeri* Heer, a species found in the upper Miocene of Switzerland and in other European localities, *Lastraea* (*Goniopteris*) *polypodioides* Ett., a form obtained from lower Miocene beds in Europe, in some Slavonic Provinces (Dalmatia), *Pteris urophylloides* sp. nov. A species very like *Pteris Urophylla* Ung., from the lower and middle Miocene of Europe. *Pteris oeningensis* Ung., a characteristic species of the upper Miocene of Germany and Europe.

The composition of the "Fossil Wood" was very varied. As far as we could judge from the collection of leaves the flora of the "Fossil Wood" had the character and position of a tropical forest on the slopes of a volcano. The volcanic eruption of cinders and lava gradually buried the neighbouring forests and torrents of mud carried the results of the eruption to the forest. This again overspread and cemented the layers of fallen cinders. Plants living near the volcano were burnt and the leaves converted into fine charcoal, which is very common in tuffs, and into pieces of half-burnt wood, not uncommon in these beds. The greater part of the plant debris is buried in the tuffs. Large trunks which occur here *in situ* do not show any traces of fire or of carbonization before petrifaction, but the smaller branches appear to have been charred before they were petrified. There is no substantial difference in the floras of the upper and lower beds of andesite tuffs.

The torrents of lava covering the tuffs containing remains of plants produced the impression that the accumulation of volcanic material, which is now cut through by the River Dzundza, occurred

[1] Marion states that *Chamaerops humilis* existed in middle Pliocene times near Marseilles: Saporta, *L'Origine paléontologique des arbres*, Paris, 1888, p. 120.

many times, but this material was sometimes replaced by a deposit of porous volcanic substance cemented with clay.

To what period can we assign these eruptions which were the cause of the preservation of so rich and heterogeneous a vegetation? Where can we find either in the Caucasus or in other parts of the old world an analogous formation?

The list we have given of the plant impressions from the "Fossil Wood" suggests a comparison of the vegetation with the Tertiary flora of Western Europe. In that flora we meet with species characteristic of North America, the Canary Islands, also some Asiatic and European forms. A similar combination of elements is also met with, to some extent, in the upper Tertiary beds of Switzerland (the Oeningen Series), but it is especially characteristic of the Pontish beds of France, Germany, Austria, and Italy, also the lower Pliocene flora (namely Plaisancien supérieur) of the central Massif of France. The Pliocene flora preserved in lava cinders (gisements cinéritiques) in beds associated with andesite lavas of Pas de Mougudo and St. Vincent la Sabie in the Cantal[1] is the most nearly allied to ours, and it also represents a falling off in the number of known European forms in comparison with the Miocene flora. According to Laurent in the flora he describes there is a striking predominance of Lauraceae, Urticaceae, and Amentaceae.[2] The climate of the Cantal according to Laurent was almost that of an island, soft, tropical, or sub-tropical and rather damp.

If we compare these beds with our existing flora we are struck by certain differences in facies; the flora of the Godersky summit is characterized by the absence of Northern Palaearctic elements such as chestnut, beech, alder, ash, and other trees. On the other hand, it should be pointed out that Paulownia and Oreodaphne, which are very characteristic Pliocene genera, do occur in our flora. If we compare our flora with those of the same Lower Pliocene age in Europe we find similar forms in Pliocene beds of France and the adjacent part of Spain (the ravine of Esplugas near Barcelona) which contain a high percentage of similar types.[3] The species common to our flora and the Franco-Spanish flora are: *Aspidium Meyeri* Heer, *Ficus multinervis* Heer, *Cinnamomum Scheuchzeri* Heer, *Eleagnus acuminata* Web., *Andromeda protogaea* Ung., *Berchemia multinervis* Heer, which is very close to our *B. Winogradowi* sp. nov. Probably further analysis will reveal additional types common to both floras. In France some palms have been found in beds equivalent to ours. The average temperature of these places was 17° to 18° C., as, for example, in Madeira and the Canary Islands at the present day. The predominance in our flora of mesophyll plants as well as ferns points not only to a warmer, but

[1] Laurent, *Ann. Mus. d'Hist. Nat. Marseilles Géologie*, t. ix, 1904–5.
[2] Laurent, *ibid.*, t. xii, 1908, p. 12.
[3] Laurent, *Catalog de la Flora Pliocena de los Alrededores de Barcelona* (J. Almeda), Madrid, 1897.

also to a damper climate than we have at present. The Pliocene physical features of Transcaucasia were very different from those of modern times, and the sea had not entirely left the plains which are now dry land. Probably there were large expanses of sea near the Godersky forests.

In a word we have here a stage of evolution of a contemporary type of the Pont and probably a Talysh flora, but a very early one compared with that of the present mesophyll forests of the Caucasus. The existing forests have been formed, as we can now see, mostly during upper and middle Pliocene periods, the floras of which in all parts of Europe indicate a very sharp transition from Miocene floras to those of modern times. The flora of the Godersky summit witnessed considerable volcanic activity in the Caucasus and the accumulation of masses of erupted material that formed the high ground of the country. The curtain of the past has been lifted and we are able to see one of the phases of the decline of the older tropical flora, the advent of new forms which took part in the development of the present-day vegetation.

I am much obliged to Professor Seward for the revision of my MS. and for seeing it through the press.

Sedgwick Museum Notes.

A New Azygograptus from North Wales.

By Gertrude L. Elles, D.Sc., Newnham College, Cambridge.

THE graptolite here described was discovered first in the St. Tudwal's peninsula by Mr. T. C. Nicholas in 1912 in the Llanengan Mudstones, but it was not then regarded as distinct from *Azygog. lapworthi*, though it seemed to possess certain features not recognizable in the Lake District specimens, the only area from which that species had been previously recorded. The discovery of numerous other specimens by Dr. Matley in the Lleyn peninsula and by Dr. Greenly in the Bangor area has served to show that the characters wherein this species differed from *Azygog. lapworthi* are permanent and of specific value, and since, moreover, it occurs at a distinctly higher horizon than *Azygog. lapworthi*, being characteristic of about the middle of the zone of *Didymog. extensus*, a description of it seems advisable. In general it has been noted that it is in many respects intermediate in character between *Azygog. lapworthi* on the one hand and *Azygog. suecicus* on the other, and it is perhaps significant that it occurs upon an horizon between the two.

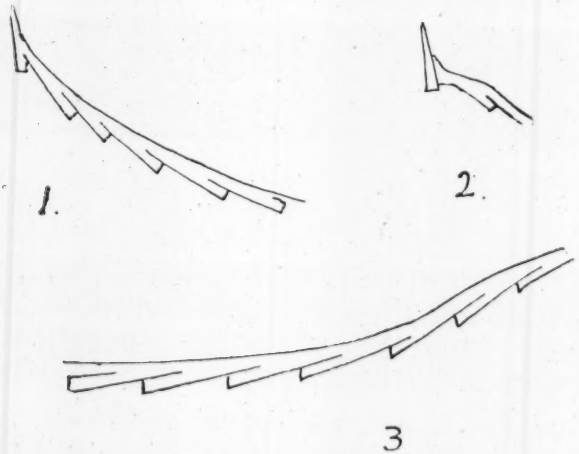
Azygograptus eivionicus.[1]

Stipe slightly deflexed, 2–4 cm. or more in length; of a uniform breadth of about 0·8 mm., originating from the centre of a slender sicula but not curving away till the level of the aperture is almost reached.

[1] Eivion is a well-known name for the Lleyn region.

Thecae 7–5 in 10 mm., four times as long as wide, simple tubes of approximately even breadth overlapping $\frac{1}{3}$–$\frac{1}{2}$ their length; outer walls straight; apertural margin even, perpendicular.

Description.—The stipe is always definitely flexed, though less conspicuously than in *Azygog. lapworthi*; the growth of the earliest thecae resembles somewhat that of *Azygog. suecicus*, but the aperture of the sicula is, as a rule, freer than in that species, though there is some variation in this respect due to the method of preservation and the effects of compression. The thecae measure 2·5 mm. in length when fully developed, but are shorter than this in the region of the sicula; their inclination is invariably low, not exceeding 10°.



Azygograptus eivionicus. 1. Specimen showing "spring" of stipe; type, 2. Proximal end. 3. Distal fragment. All × 5.

Affinities.—This species approaches *Azygog. lapworthi* in the curvature of the stipe, but the stipe never springs away directly from the sicula as in that species, and the thecae are of a more uniform breadth throughout their length; they are also less numerous in a given unit of length and inclined at a lower angle. From *Azygog. suecicus* this species may be separated by the greater degree of curvature of the stipe and the more distant thecae; as a rule also the aperture of the sicula is free, which is not the case in *Azygog. suecicus*.

Horizon and Localities.—*Azygog. eivionicus* occurs often in dense "mats" in the Arenig rocks of North Wales in the zone of *Didymog. extensus*. It has been found at various localities in the Lleyn peninsula, including Nant, south of Llanengan, and in the Bangor area, at Garth Point, north of Bangor, and at University College Cliff.

The type specimens are in the Sedgwick Museum, and others are

in the collections of Dr. Matley and Dr. Greenly, now in the possession of the Geological Survey of England and Wales.

My best thanks are due to Mr. T. C. Nicholas, Dr. Matley, and Dr. Greenly for the loan of specimens and to Dr. Flett for permission to study those in the Collection of the Geological Survey.

The Structure of the South-West Highlands.

TWO REPORTS ON AN EXCURSION, 27TH AUGUST TO 2ND SEPTEMBER, 1921.

Report A.

By W. B. WRIGHT, B.A., E. M. ANDERSON, M.A., B.Sc., J. E. RICHEY, M.C., B.A., and H. H. READ, M.Sc., A.R.C.S.

LAST summer we spent seven days with Mr. E. B. Bailey investigating some of the evidence upon which he bases his interpretation of the structure of the South-West Highlands, and we feel that our experience should be at the disposal of others interested in the subject. Mr. Bailey's full account of his theory will shortly appear in the *Quarterly Journal of the Geological Society of London*, and an abstract has already been printed in the *Proceedings* of that Society, dated April, 1921. In this abstract, the South-West Highlands are allotted to three great structural divisions in descending order as follows:—

Loch Awe Nappe.
Iltay Nappe.
Ballappel Foundation.

The two lower of these divisions are claimed as structural complexes; for instance, the Iltay Nappe is stated to include two major recumbent folds of which the lower may be seen closing north-westwards in Ben Lui. In addition, it is pointed out that the three great structural divisions are themselves involved in later, or secondary, folds, among which the Loch Awe Syncline is a prominent example.

It is hoped that this outline of Mr. Bailey's position, supplemented by data presented in his already published papers, will enable the reader to follow the main points of our statement as given below.

1. Inspection of the northern termination of the Tayvallich Lava outcrop, south of Tayvallich, and of the Loch Avich Slate outcrop, east of Loch Awe, has satisfied us of the reality of Mr. Bailey's stratigraphical subdivision of the Loch Awe Group.[1]

2. In spite of small-scale isoclinal folding it is easy to establish a descending structural succession within the Loch Awe Group downwards from the Loch Avich Slates.[2]

[1] *Q.J.G.S.*, vol. lix, 1913, pp. 291, 303.
[2] Ibid., pp. 292, 293.

3. The coast-section of the Tayvallich Lavas supplies almost conclusive evidence that the structural sequence noted above is not an inversion.[1]

4. Examination of the district between Loch Awe and Beinn Udlaidh shows sufficiently clearly that the Ardrishaig–Loch Awe Assemblage (Mr. Bailey's Loch Awe Nappe) structurally overlies the remainder of the South-West Highlands.

5. Most of us were already familiar with the Ballachulish recumbent fold and slide.[2] We saw further evidence, and we regard these structures as demonstrated. We also found the recumbent folds of Beinn Udlaidh[3] and Ben Lui so well exposed that we do not think either of them open to question. We were impressed with the fact that, at Ben Lui, Mr. Bailey has interpreted, but not altered, the original Survey mapping.

6. The recumbent fold of Ben Lui furnishes a complete explanation of the failure of the Cowal Schists to reappear north-west of the Loch Awe Syncline.

7. As regards the thrust which Mr. Bailey invokes at the base of his Loch Awe Nappe, we do not think an alternative interpretation has been advanced which meets the observable facts, in particular, the three-sided nature of the Ardrishaig-Ben Lawers complex.

8. We accept the connexion which Mr. Bailey has traced between Perthshire and Islay round the north end of the Loch Awe Syncline in what he calls the Iltay Nappe, though one of us (E. M. A.) thinks that the possibility of a reinterpretation of the supposed Iltay outcrop on Loch Etive should not be lost sight of.

9. Some of us were strongly impressed by the evidence of marked disruption adduced by Mr. Bailey near the base of his Iltay Nappe in the lowly metamorphosed region of Ardmucknish.

10. Where constructive metamorphism is marked, obvious crushing is characteristically absent from Mr. Bailey's slides. Clough has compared Bailey's non-mylonitic slide-zones with some of pre-Torridonian age in the North-West Highlands.[4] In contrasting these particular mylonitic movement-zones of the North-West Highlands with the mylonitic type well represented among the post-Cambrian thrusts of the same district, Teall and Horne say: "These two types no doubt correspond to differences of pressure and temperature at the time of deformation."[5]

11. We were unable to test Mr. Bailey's tentative inter-nappe correlations, or his Islay chronological evidence, upon which, in conjunction with the Ben Lui Fold, he bases much of his case for the nappe-movement having proceeded from the north-west. In these and other matters we should like to suspend judgment.

[1] B. N. Peach & E. B. Bailey, "Geology of Knapdale, etc.": *Mem. Geol. Surv.*, 1911, pp. 60, 69.

[2] *Q.J.G.S.*, vol. lvi, 1910, p. 593.

[3] E. B. Bailey & W. Macgregor, *Q.J.G.S.*, vol. lviii, 1912, p. 168.

[4] *Q.J.G.S.*, vol. lviii, 1912, p. 177.

[5] N.W. Highland Memoir, 1907, p. 598.

12. Our general impression is that a very welcome element of simplicity has been at last introduced into the tangle of Highland geology, and that the conclusions reached must in the main hold good.

Report B.

By Professor L. W. Collet, of Geneva.

I was already impressed by the tectonic features of Mr. Bailey's maps before I saw the field evidence. When I visited the ground it was with companions (see above) who were able to control the stratigraphical points, and I feel that there can be no doubt of the reality of the Beinn Udlaidh, Ballachulish, and Ben Lui recumbent folds, and of their resemblance—as pointed out by my colleague, Professor Argand, on reading Mr. Bailey's papers—with those of the Alps.

It seems to me a capital point for the future that a connexion has been obtained between the Ben Lui and Ben Doirean districts on the basis of a culmination of pitch in the neighbourhood of Ben Udlaidh. A similar change of pitch allowed Dr. Staub to follow the recumbent folds of the Pennine Alps far beyond the region where they had been discovered by Professor Argand. It is not impossible that the Loch Awe Nappe will reappear in the Eastern Highlands.

Mr. Bailey's paper seems to me to be a great forward step, not only for Scotch geology, but also for geological science.

Notes on the Fauna of the Lower Devonian Beds of Torquay.

By F. R. Cowper Reed, Sc.D., F.G.S.

(*Concluded from p. 275.*)

Tellinopsis devonica sp. nov. (Text-figure.)

Definition.—Shell large, elliptical, subquadrate; valves moderately convex; inferior margin very slightly curved, almost straight; posterior end well rounded above, truncated below and straight, meeting inferior margin at rather more than a right-angle; cardinal margin very slightly arched, nearly straight, but passing gradually into posterior margin; anterior end rounded. Beak large, rounded, prominent, subcentral, elevated above hinge-line, incurved, not directed forwards. Umbonal ridge narrow, straight, running obliquely backwards to posterior lower angle of valve and causing a slight angulation of the surface. Shell ornamented with regular equidistant sharp concentric lamellose striæ about 30–40 in number, rather suddenly bent at an obtuse angle on crossing the umbonal ridge.

Dimensions.—Length, *c.* 65 mm. Height, *c.* 42 mm.

Horizon.—Meadfoot Beds (bluish slate).

Locality.—Kilmorie (S. 76).

Remarks.—A single right valve, of which the anterior margin is somewhat broken, is the sole material in which the above diagnosis

is based. The ornamentation is preserved only on the lower half of the surface, the concentric lines there numbering 14, from which the total number on this shell is estimated to be about 30–40. The general shape of the shell, the large prominent subcentral beak and the course of the umbonal ridge much resemble the species *Tellinopsis subemarginata* (Conr.)[1] of the Hamilton group of New York, though the ornamentation is more like that of *Ctenodonta gibbosa* (Goldf.).[2] It should be remarked that the variety *Kayseri* Beush. of the latter species (which seems to resemble our shell) is put by Williams and Breger[3] in the genus *Tellinites* of which they

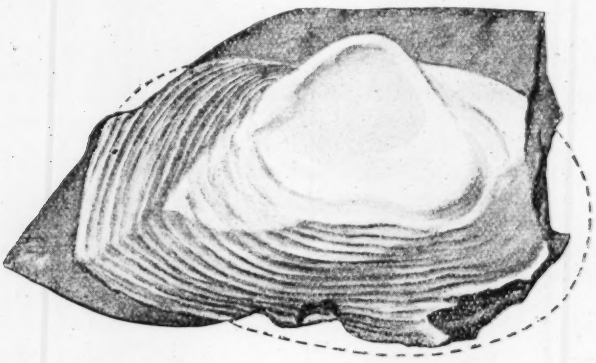


Fig. 1.—*Tellinopsis devonica* sp. nov. Nat. size. Meadfoot Beds, Kilmorie. (Sedgwick Museum, Cambridge, S. 76.)

regard *Tellinopsis* as merely a subgroup. The large subcentral non-prosogyrous beak of *Tellinopsis* seems an important external difference from *Ctenodonta* and from its subgenus *Kœnenia* Beushausen, which the above-mentioned American authors consider to be a synonym for *Tellinites* McCoy.

Tellinites ? lævisulcus (Etheridge).

No precise diagnosis of the specific characters of this shell was given by Etheridge,[4] but he made some general remarks on the specimens and on the probable affinities of the species, stating that the posterior side of the shell "seemed to show the ridge which characterizes *Cypricardia*" and that the species somewhat resembled *Orthonota* (*Cypricardia*) *semisulcata* Sowerby, as figured by Phillips (*Palæoz. Foss. Cornw. Dev.*, pl. 17, fig. 57). But the beaks are apparently subcentral, the umbonal ridge is practically obsolete,

[1] Hall, *Palæont. New York*, vol. v, pt. ii, 1879, p. 464, pl. lxxvi, figs. 21–31.

[2] Beushausen, op. cit., t. vi, fig. 16.

[3] Williams and Breger, op. cit., pp. 163, 165, pl. xix, figs. 3, 9, 11, 13, 15, 16. (? pl. xxv, figs. 1, 3, 4, 5, 12).

[4] Etheridge, Geol. Mag., 1882, p. 154, pl. iv, fig. 4 (? 5) (*Cypricardia lævisulcus*).

and there seems to be no marginal sinuation at the lower posterior angle. The surface ornamentation consists of rather widely separated sharply raised concentric lines, or rather ridges, with smooth deep concave interspaces between them. The shape of the shell suggests the genus *Tellinites* as redefined by Williams and Breger,[1] rather than *Cypricardia*, and *T. Chapmani* Will. and Br.,[2] which its authors considered closely similar to the European *Ctenodonta* (*Palæoneilo*) *elegans* Maurer,[3] appears to resemble the British specimens, while the ornament recalls that of *Ctenodonta unioniformis* Sandb.[4] and its allies.

Horizon.—Red Beds (Staddon Grits).

Locality.—Smugglers' Cove, Torquay.

Goniophora bipartita (F. Roemer).

One internal cast of a left valve, though imperfect, in the Sedgwick Museum collection from Kilmorie, shows the characteristic features of this species as described by Beushausen.[5] Our specimen particularly resembles the broader shorter form which he represented in his fig. 15 (op. cit.), the general shape and the curvature of the umbonal ridge being specially noteworthy.

Dimensions.—Length, *c.* 48 mm. Height, *c.* 30 mm.

Horizon.—Meadfoot Beds.

Locality.—Kilmorie (S. 69).

Goniophora rhenana Beushausen.

The considerable differences which occur in the appearance of opposite valves of the same individual as the result of unequal crushing and deformation are exhibited in the internal cast of a complete shell from Kilmorie belonging to the genus *Goniophora*. The right valve resembles that in one of Beushausen's figures of *G. nassoviensis* Kayser[6] in its general shape, the nearly straight course of the low obtuse umbonal ridge, the length of the hinge-line, the size and inclination of the upper portion of the valve, the acutely pointed posterior end and the angle made by the posterior margin with the hinge-line. The left valve, on the other hand, is more like one of his figures[7] of *G. bipartita*, being deeper, with the umbonal ridge more prominent and strongly arched upwards and the portions of the valve above and below it inclined nearly at a right angle. According to Beushausen *G. rhenana*[8] lies between these two species. The muscle-scars and pallial line which are well seen in our specimen agree with those shown in a figure (fig. 9) of the interior of *G. nassoviensis*

[1] Williams and Breger, op. cit., p. 163.
[2] Ibid., p. 163, pl. xix, fig. 8.
[3] Beushausen, op. cit., p. 81, pl. vii, figs. 6, 7.
[4] Ibid., p. 84, pl. vi, figs. 10–15.
[5] Beushausen, op. cit., p. 200, t. xvii, figs. 14–16, 35; Maurer, *Ber. Senck. Naturf. Gesell.*, 1902, p. 60, t. vi, figs. 1, 2; Kegel, op. cit., p. 91.
[6] Beushausen, op. cit., p. 203, t. xvii, figs. 4–9.
[7] Ibid., t. xvii, fig. 14.
[8] Ibid., p. 201, t. xvii, figs. 10, 11.

given by Beushausen, but no internal view of *G. rhenana* is represented by this author.

G. nassoviensis is stated to be distinguishable from *G. rhenana* by its more obliquely elongated form and its higher and sharper keel, and on the whole it seems that our shell is more probably a member of the latter species.

Dimensions.—Length of shell (oblique), 40 mm. Height at anterior end 14 mm. Height at posterior end of hinge-line, 18 mm. Thickness, 14 mm. Length of hinge-line, 25 mm.

Horizon.—Meadfoot Beds.

Locality.—Kilmorie (S. 70).

Goniophora kilmoriensis sp. nov. Plate XII, Figs. 2, 2*a*, *b*.

Diagnosis.—Shell narrow, much elongated, acutely pointed behind, more than four times as long as high, slightly oblique, subtriangular in cross-section, thickest towards middle narrowing posteriorly and towards beak; each valve divided into unequal portions by a sharply angular gently arched longitudinal ridge running obliquely across the surface from the beak to the posterior end and having the areas above and below the ridge more or less flattened and inclined to each other at 60–90 degrees. Beaks small, subanterior, acute, pointed. Hinge-line nearly two-thirds the length of the shell, making an angle of 15–20 degrees with the umbonal ridge. Ligamental area well-defined, sunken, long, very narrow, lanceolate. Left valve with strong rounded triangular anterior tooth below the beak fitting into a corresponding socket in right valve. Large anterior elongated oval muscle-scar, situated at front end close to inferior margin, with a length equal to about one-sixth that of the shell, deeply sunken, and marked off above by a strong curved ridge; pedal muscle-scar small, situated on its superior anterior edge. Surface of valves ornamented with strong coarse concentric striæ, the portion below the umbonal ridge being crossed anteriorly by sublamellose somewhat irregular but mostly equidistant thick lines making an angle of 45–60 degrees with the umbonal ridge, the angle becoming smaller posteriorly till they are parallel to inferior margin of shell; the portion above the umbonal ridge is crossed by similar but more regular and equal lines meeting the ridge at a more acute angle (30–20 degrees) throughout the length of the valve.

Dimensions.—Length, *c.* 90 mm. Height (maximum), *c.* 22 mm. Thickness (maximum), *c.* 20 mm.

Horizon.—Meadfoot Beds.

Locality.—Kilmorie (S. 68).

Remarks.—The material from which the above description has been drawn up consists of one internal cast of a complete shell, which is perfect with the exception of the beaks and posterior end, and the external impression of the surface of the same individual. It was collected by Professor Hughes' party at Kilmorie, Torquay, in 1893.

With regard to its affinities, the examples of *G. Stürtzi* Beushausen [1] figured by Drevermann [2] from the Coblenzian of the Eifel seem somewhat similar, but Beushausen's figure of this species was only an unsatisfactory one in the text. *G. acuta* Sandberger [3] is an allied form and *G. secans* Fuchs [4] bears a considerable resemblance. But with none of these can ours be safely considered identical, and it seems desirable to separate it specifically.

Goniophora sp.

Another species of *Goniophora* seems to be present at Kilmorie, and is represented by a somewhat imperfect right valve in the Sedgwick Museum in which the lower part of the anterior end and the upper and lower angles of the posterior end are rather broken. The shell is relatively longer and narrower than *G. bipartita* and scarcely widens at all posteriorly, the upper and lower margins being subparallel; the hinge-line is very long and straight, being nearly three-fourths the length of the shell; the umbonal ridge is strong, causing a sharp angulation of the surface, and appears to be nearly straight, the curvature from the beak to the posterior angle being very slight. The posterior margin is very oblique, gently arched, and makes an angle of about 140 degrees with the hinge-line. The external ornamentation is not preserved. The affinities of this shell seem to be with *G. nassoviensis* Kayser[5] and *G. trapezoidalis* Kayser,[6] but it is impossible to identify the species.

Dimensions.—Length, *c.* 55–60 mm. Height (maximum), *c.* 23 mm.

Horizon.—Meadfoot Beds.

Locality.—Kilmorie, Meadfoot (S. 69).

Diaphorostoma cf. *naticopsis* (Oehlert) ?

One somewhat distorted internal cast of a low naticoid gastropod from Kilmorie may be referred without much hesitation to the genus *Diaphorostoma* which Fischer proposed in 1885 in place of the pre-occupied name *Platyostoma*. We may apparently compare our specimen with Oehlert's *Platystoma ? naticopsis* [7] of the Lower Devonian of Mayenne, and with *D. ventricosum* (Conr.) [8] of the American Lower Devonian.

Dimensions.—Diameter, *c.* 25 mm. Height, *c.* 17 mm.

Horizon.—Meadfoot Beds.

Locality.—Kilmorie, Torquay (S. 75).

[1] Beushausen, op. cit., p. 210, text fig. 17*a–c*.

[2] Drevermann, *Palæontographica*, xlix, 1902, p. 91, t. xi, figs. 4–6.

[3] Beushausen, op. cit., p. 211, t. xvii, figs. 1–3.

[4] Fuchs, *Abh. k. preuss. geol. Landesanst.*, N.F., Heft lxxix, 1915, p. 56, t. x, figs. 20-1.

[5] Beushausen, op. cit., p. 203, t. xvii, figs. 4–9.

[6] Ibid., p. 205, t. xvii, fig. 34.

[7] Oehlert, *Bull. Soc. Geol. France*, ser. III, vol. v, 1877, p. 588, pl. ix, fig. 10.

[8] Hall, *Palæont. New York*, vol. iii, pt. ii, 1859, p. 300; pl. lv, figs. 9*a–d*; p. 469, pl. xcii, figs. 1–10; pl. cxiii, figs. 7, 8; pl. cxv, fig. 8. Williams and Breger, op. cit., p. 262, pl. xiii, figs. 18.

Platyceras dorsicarina Fuchs.

The internal cast of a large species of *Platyceras* from Kilmorie which seems identical with *Pl. dorsicarina* Fuchs,[1] of the Rhenish Lower Devonian shows the typical tall narrow compressed shape, the sharp carination of the dorsum and the large high slightly twisted pointed apex, as Fuchs illustrates. It is allied to *Pl. Zinkeni* (A. Roem.)[2] of the Harz.

Dimensions.—Height, *c.* 43 mm. Diameter (anterior-posterior), *c.* 22 mm.; ditto (transverse), *c.* 10 mm.

Horizon.—Meadfoot Beds.

Locality.—Kilmorie (S. 74).

Bellerophon (*Pedasiola*) aff. *tumidus* (Sandberger)?

Description.—Shell small, coiled in flat spiral, somewhat compressed, composed of four whorls rather rapidly increasing in size and especially in height towards the mouth. Dorsum narrowly rounded, strongly convex, trilobed faintly by a pair of rather weak revolving grooves, the median dorsal portion being strongly elevated and about twice the width of the lower lateral portions. Umbilical edge angulated; umbilical slope steep, abrupt; umbilicus rather large, open, exposing all the whorls. Slit-band absent?

Horizon.—Meadfoot Beds.

Locality.—Meadfoot, Torquay (M.P.G. $\frac{30}{19}$).

Remarks.—The above described single specimen of a Lower Devonian Bellerophontid in the form of an internal cast which is in the Jermyn Street Museum, seems to be Phillips' figured but undescribed specimen, named by him *B. trilobatus* Sow. var. *β*.[3] It is undoubtedly distinct from this Silurian species, but possibly is referable to one of the varieties of *B. tumidus* Sandb.,[4] which is usually placed now in the genus or subgenus *Plectonotus* Clarke,[5] which owing to the possession of a slit-band is separable from the true *Bucaniella*. Fuchs,[6] however, still includes this species in the subgenus *Bucaniella*, which he spells *Bucanella*. Spriesterbach[7] has suggested a new generic name, *Pedasiola*, for very similar trilobed Devonian species with an expanded mouth, including *Salpingostoma tripleura* Fuchs.[8] Dahmer[9] has recently described

[1] Fuchs, *Abh. k. preuss. geol. Landesanst.*, N.F., Heft lxxix, 1915, p. 64, t. xiii, figs. 14–17.

[2] A. Roemer, *Verstein. Harzgeb.*, 1843, p. 27, t. vii, fig. 4; Kayser, *Abh. geol. spec. Kart. Preuss.*, ii, Heft iv, 1878, p. 93, t. xv, figs. 5–7.

[3] Phillips, *Palæoz. Foss. Dev. Cornw.*, p. 107, pl. xl, fig. 200*b*.

[4] Kegel, op. cit., p. 42.

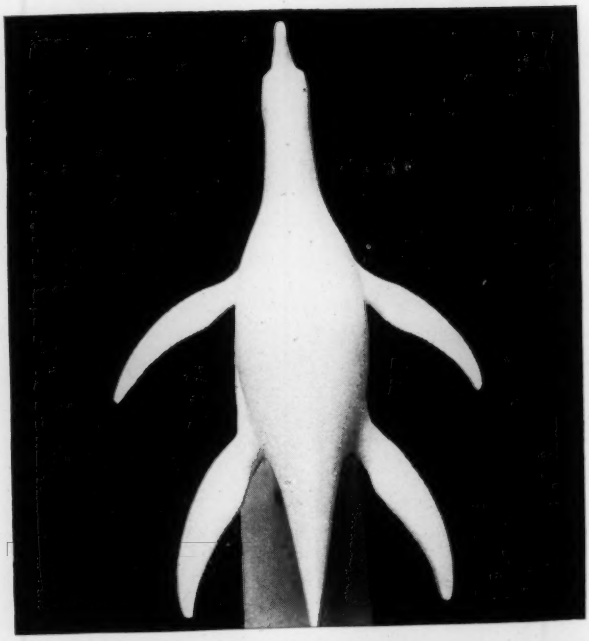
[5] Clarke, *Foss. Dev. Parana, Mon. Serv. Geol. Miner. Brasil*, vol. i, 1913, pp. 167–70.

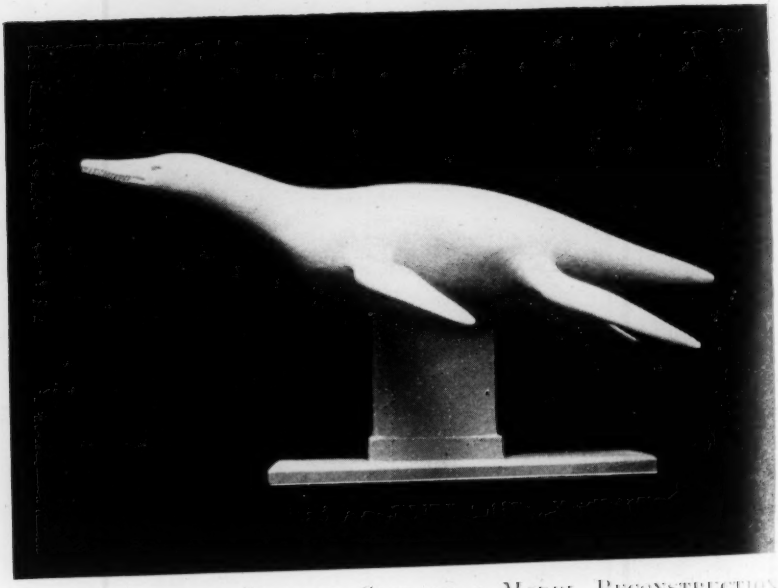
[6] Fuchs, op. cit., p. 61, t. xiii, figs. 3, 5, and references.

[7] Spriesterbach and Fuchs, *Abh. preuss. geol. Landesanst.*, N.F., Heft lviii, 1909, p. 75.

[8] Ibid., p. 75, t. ii, figs. 1, 2.

[9] Dahmer, *Jahrb. preuss. geol. Land sanst.*, f. 1919, Bd. xl, 2, Heft 2, (1921), p. 227, t. vii, figs. 10–12.





TWO VIEWS OF A PLASTER CAST OF A MODEL RECONSTRUCTION OF *PELONEUSTES PHILARCHUS*.

To face p. 303.]

an allied Lower Devonian species under the name *P. hercynica*. Our Meadfoot shell may belong to this genus.

P.S.—The recent paper by Dr. Asselberghs (GEOL. MAG., Vol. LVIII, 1921, pp. 165–9) on the correlation of the Lower Devonian beds of South Devon with those of the Ardennes and Rhine is of special interest in connexion with the revision of part of the fauna in my three articles.—F.R.C.R.

A Model of *Peloneustes philarchus*.

By the Rev. H. NEVILLE HUTCHINSON, M.A., F.G.S., F.Z.S.

(PLATE XIV.)

PLATE XIV shows two photographs of a model I have recently made in order to show the outward aspect of *Peloneustes philarchus*, a pliosaur from the Oxford Clay. It is based on the complete mounted skeleton now in the British Museum (Natural History), Cromwell Road, a part of the well-known Leeds collection.[1] This skeleton has a length of 10 ft. 6 in., and my model is 23 in. long, so the scale is roughly about 1 : 5. No other museum possesses a mounted skeleton of this genus, the nearest thing to which is the *Trinacromerum*, described as a Cretaceous plesiosaur by Dr. S. W. Williston in his work on *Water Reptiles of the Past and Present*, Chicago, 1915, where a restoration is shown on p. 89, fig. 42. The specimen is in the Museum of the University of Kansas. This same Leeds collection has given us two fine mounted skeletons of the genus *Cryptoclidus*, of the family Elasmosauridæ, and now we have also this fine mounted skeleton of *Peloneustes*, which belongs to the Pliosauridæ. Hence it is now possible for geologists to see at a glance the chief characteristics of these two families, and my hope is that this model may be of some use to students of Palæontology. In making the model I have had the advantage of much valuable assistance from my friend, Mr. E. Godwin, an accomplished sculptor, without whose assistance I doubt if it could ever have been completed; for when I attempted to model the head I found a task that was beyond my power to accomplish properly, not having had any training in the art of sculpture. We have made many measurements and calculations in our endeavour to restore this most interesting marine reptile, the leading features of which can be summed up in a few words. Instead of the familiar long neck and small head of the plesiosaur we have here a short thick neck supporting a large and long head. Notice the powerful jaws armed with big teeth which get larger towards the end or middle of the snout. There is evidence to show that *Peloneustes* fed largely on cephalopods, but doubtless pursued larger prey at times—probably fishes. The hind paddle is larger than the fore paddle, and

[1] For a full description see *Catalogue of Marine Reptiles from the Oxford Clay*, part ii, by Dr. C. W. Andrews, F.R.S., published by the Trustees of the British Museum, 1913.

Dr. Andrews concludes that this reptile swam in deep water instead of merely paddling along on the surface like the plesiosaurs. In conclusion, I will only add that we have tried to follow out the idea of "stream-lines", so important to those who design ships, submarines, and air-ships, etc. The teeth are rather too conspicuous, but this was done with a purpose, because otherwise they would hardly be visible, for in life they would be largely hidden by the flesh surrounding the bone of the jaws.

Similar casts have been presented to the British Museum (Natural History), to the New Museum, Oxford, and to the Geological Society.

Notes on the Ordovician Lavas of the Mynydd Prescelly, N. Pembrokeshire.

By Gerald M. Part, M.A., F.G.S.

PEMBROKESHIRE is, on the whole—for Wales—a comparatively low-lying county, a somewhat dissected peneplain not usually rising much above four or five hundred feet above sea-level. Apart from the ragged stacks which rise up above the level of this peneplain in the northern part of the county—Carn Llidi and Pen-berry near St. Davids and the Strumble Head masses near Fishguard, for example—there is only one really prominent feature in the whole Pembrokeshire landscape, the Mynydd Prescelly, which rise near the western end of their ridge above Rosebush to a height of 1,760 feet.

It is therefore somewhat surprising to find a great scarcity of geological literature dealing with this part of the county, and the only work of note which I have been able to discover is a paper by J. Parkinson.[1] The bulk of this is concerned with the spherulitic rhyolites which occur on Carn Alw and Foel Trigarn at the north-east end of the hills, though Parkinson briefly mentions "certain more basic rocks" which he describes as being "of somewhat uniform and monotonous appearance", and also the gabbroid dolerites which form many of the prominent "Carns" along the summit of the ridge.

These have recently added interest to the problems of Stonehenge, Dr. H. H. Thomas having identified the "blue stones" of this monument with the peculiar spotted dolerite which forms Carn Meini and other "Carns" at the eastern end of the Prescellys.[2]

It is to be regretted that even the glamour of Stonehenge can hardly make up for all the epidote, chlorite, and other decomposition products with which these rocks are affected. Hitherto there has been some doubt as to their exact age, though it is probable that, like the other dolerites of North Pembrokeshire, these intrusions are older than the main folding which is of Valentian or

[1] *Q.J.G.S.*, vol. liii, 1897, p. 465.
[2] *Geol. Survey—Summary of Progress*, 1920, p. 56.

post-Valentian but pre-Old Red Sandstone age. It is hoped that the detailed examination of the area, now in hand, will provide further evidence bearing on this question.

A preliminary visit to the district during the past summer served to dispel much of the monotony from the rocks briefly noticed by Parkinson, and as most of them differ somewhat from the other occurrences in that part of Wales, it seems desirable to publish a fuller description than appears in his paper. The district is contained in Sheet 210 (New Series) 1 in. Ordnance Survey, and Sheet 40 Old Series (geologically coloured), though the boundaries shown on the latter are, in many cases, erroneous.

Soda-trachytes, keratophyres, and allied types have been described from various parts of Pembrokeshire and Carmarthenshire—notably from the Abercastle district,[1] Treffgarne,[2] Skomer and the mainland adjacent,[3] and Coomb.[4] These are of Arenig age, but in addition soda-rhyolites are known from several horizons ranging from pre-Cambrian to Llanvirn.

Unlike the Arenig occurrences mentioned above, the lavas from the Prescellys apparently occur in the Llanvirn series, but the evidence is not complete. Owing to the strong cleavage by which all the sedimentary rocks have been converted into slates in this northern half of the county, fossils are both scarce and very ill-preserved. The whole district abounds in slate quarries (many—like the large ones at Rosebush—disused), and there are trial-holes all over the hills round that village. Lately there has been a revival in this local industry, and several quarries are at work near Maenclochog and Llandilo.

In addition to the cleavage the area has been subjected to a considerable amount of faulting of the usual North Pembrokeshire type, i.e. east-west strike-faults accompanied by numerous, but not usually individually important, dip-faults.

(A) The Soda-rhyolites and Felsites.

(*a*) There is little to add to the description given by Parkinson of the spherulitic and other varieties from Carn Alw and Foel Trigarn. Dr. Elsden has already drawn attention to the similarity of many of these rocks to the rhyolites of Llanrian near Abereiddy Bay.[5]

One interesting feature which has hitherto escaped notice is the presence of the Foel Trigarn rocks of numerous relatively large crystals of zircon—ranging up to ·01 in. in length.

East of Rosebush, near the farm Eithbed-fach, there are exposures of silicified rhyolites and rhyolitic ashes. Other ashes—usually porcellanous and quite featureless under the microscope—occur

[1] J. V. Elsden, *Q.J.G.S.*, vol. lxi, 1905, p. 594; A. H. Cox, ibid., vol. lxxi, 1915, p. 307.
[2] *Mem. Geol. Surv.*, Sheet 228 (Haverfordwest), p. 21.
[3] H. H. Thomas, *Q.J.G.S.*, vol. lxvii, 1911, p. 175.
[4] Cantrill & Thomas, *Q.J.G.S.*, vol. lxii, 1906, p. 243.
[5] Op. cit., p. 581; see also Cox, op. cit., p. 316.

in the Llanvirn slates. These are useful in the field as a means of determining the true dip of the highly-cleaved sediments. In their general character they are very similar to the "china-stone ashes" found in the Bifidus Shales in many other parts of Wales, and are probably of similar age.

(*b*) Greenway type: West of Rosebush there is an extensive peat and drift-filled depression through which the railway and River Syfynwy run. This is formed in a thick band of "felsite" or soda-rhyolite, which is well exposed at numerous points round the western rim of the depression at Cnwc-y-felin, New Inn (Greenway), and in the Syfynwy valley. Similar rocks are exposed in quarries on Goetty Mountain, at the Syfynwy Falls, and on Bernard's Well Mountain (between Tufton and Rosebush).

In the field these rocks are pale in colour, weathering with a grey or whitish crust and break down into a yellow gravelly soil. The weathered blocks frequently show lines of flow. There is an approximately rectangular jointing—very well shown in the section at the Syfynwy Falls.

Fresh specimens are pale bluish- or greenish-grey, fine-grained or even flinty in texture and containing many small phenocrysts of felspar. The rock sometimes has a "pepper and salt" appearance, due to patches of chlorite disseminated through it.

The upper surface of this band is exposed in the crags on the east side of the Banc-du, the prominent hill west of the main Haverfordwest—Cardigan road, a few hundred yards north of New Inn. The rock is here finer-grained, ochreous, and rather soft. The actual junction can be seen in the crags, and shows the irregular upper surface of the flow upon which the slates have been deposited. On the south side of the hill the slates from the immediate neighbourhood of the junction give the impression of being slightly hardened and silicified, but in general there in no evidence of intrusion, nor have I observed anything comparable to the slate-keratophyre breccias of Longhouse and other localities in the neighbourhood of Abercastle.[1] The margin of the rock at Banc-du is, however, undoubtedly slightly brecciated, as can be seen in most of the slices of specimens from this locality.

Under the microscope specimens collected from Syfynwy Falls, Goetty Mountain, Cnwc-y-felin, and several points north and west of Greenway, all proved to belong to the same general type. The rocks are conspicuously porphyritic with abundant small phenocrysts of felspar lying in a fine somewhat "felsitic" groundmass (Fig. 1). In size the phenocrysts range up to ·25 in., but in general are smaller than this, about ·04–·08 in. in length. Some which are untwinned, or simple Carlsbad twins, are a soda-orthoclase. The remainder are a plagioclase of similarly low refractive index giving extinction angles on the twin lamellæ up to 16°. These

[1] Elsden, op. cit., p. 574; Cox, op. cit., p. 307.

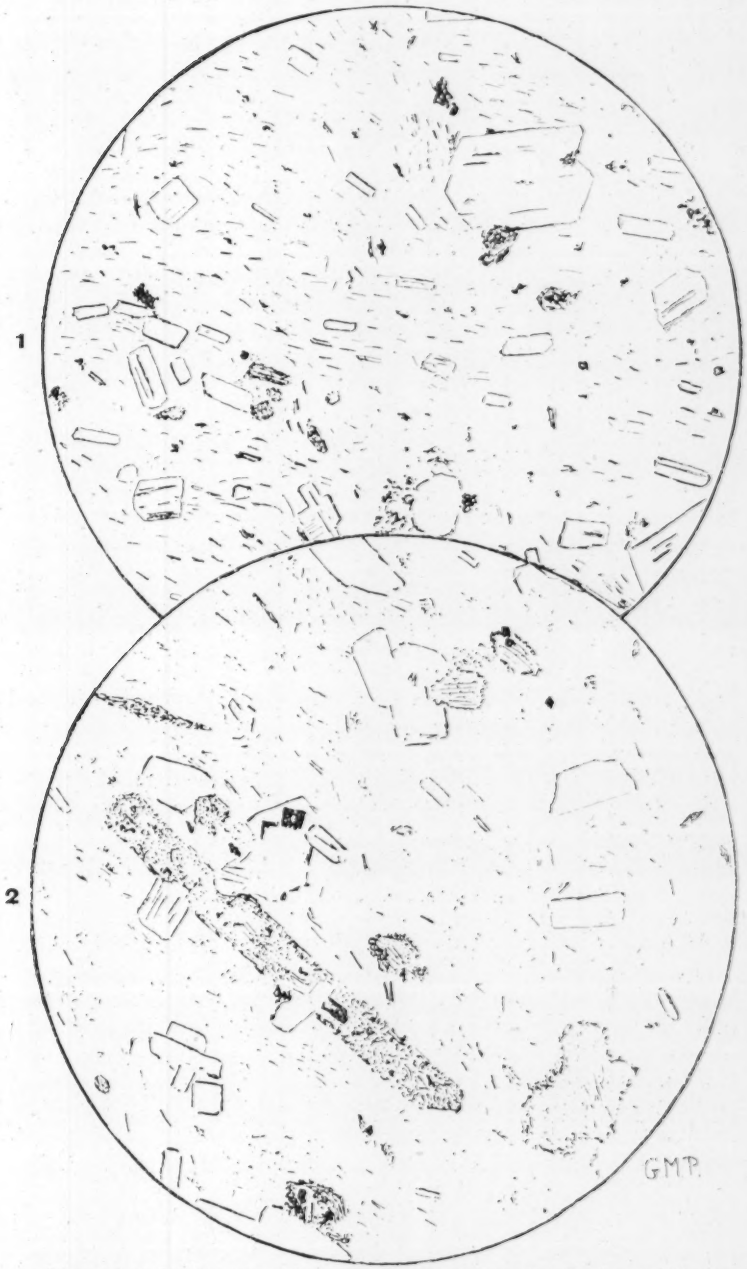


FIG. 1.—Soda-rhyolite, Quarry, Goetty Mountain, Rosebush. × 18.
FIG. 2.—Soda-rhyolite, 500 yards W.N.W. of New Inn, Greenway, W. of Rosebush. × 22

must be almost pure albite—a conclusion borne out by an examination of cleavage fragments.

The ground mass is rather variable in character. It consists of granular quartz, small laths of felspar, mainly albites about ·01 in. in length, with interstitial chlorite. There are a few needles of apatite, granules of secondary sphene, and occasional grains of an iron-ore mineral. In one or two specimens there is a little pyrites or limonite pseudomorphs after it. Vesicles are uncommon, but when they occur are filled with quartz. In structure the ground-mass usually approaches the "micro-poecilitic" type so frequently described in felsites, and their general appearance suggests that most of these rocks have suffered more or less devitrification and some of the quartz may be secondary. The granularity of the structure is, however, modified by the small laths of felspar which frequently exhibit a marked fluxional arrangement. In those cases where the flow is not very pronounced in the ground-mass, there is usually a distinct parallelism of the smaller phenocrysts.

The chlorite occurs in grains, scaly or fibrous aggregates and irregular patches lying between the other constituents. Only rarely has anything in the nature of well-formed pseudomorphs been noted, and in the majority of cases there is no evidence as to what was the original ferro-magnesian constituent of these rocks. In the rock south-west of Banc-du there are numerous pseudomorphs of a pale yellowish chloritic substance after some monoclinic mineral, and usually having an irregular border of granular green chlorite (Fig. 2). Some of these pseudomorphs have an external form which may represent hornblende, as in the rocks of Coomb, Carmarthenshire.[1] In other cases it is possible that some of the mineral was a pyroxene, and in a rock from Goetty Mountain there are a few small pseudomorphs in which the pyroxene form is rather more definitely developed. In one or two cases small pleochroic haloes have been observed in some of the more irregular patches of chlorite. It is possible that mica occurred originally, but this does not seem to have been more than a very minor constituent. In one specimen a few relatively large zircons were observed, as in the rhyolites of Foel Trigarn.

The rock exposed on the eastern side of Banc-du, forming the upper surface of the mass, is now very different in character to the rest, though it would appear to have been identical originally. It is now a very fine-grained aggregate of quartz, white mica, and a little limonite, with interstitial chlorite in the ground-mass serving to distinguish this portion from the phenocrysts. There are a few rare pseudomorphs in chlorite, similar to those found in the Coomb rocks. Sections of the actual junction with the overlying slates show the slight chilling at the surface, which has also been somewhat brecciated. This surface, however, is very irregular and the

[1] Cantrill & Thomas, op. cit., p. 243.

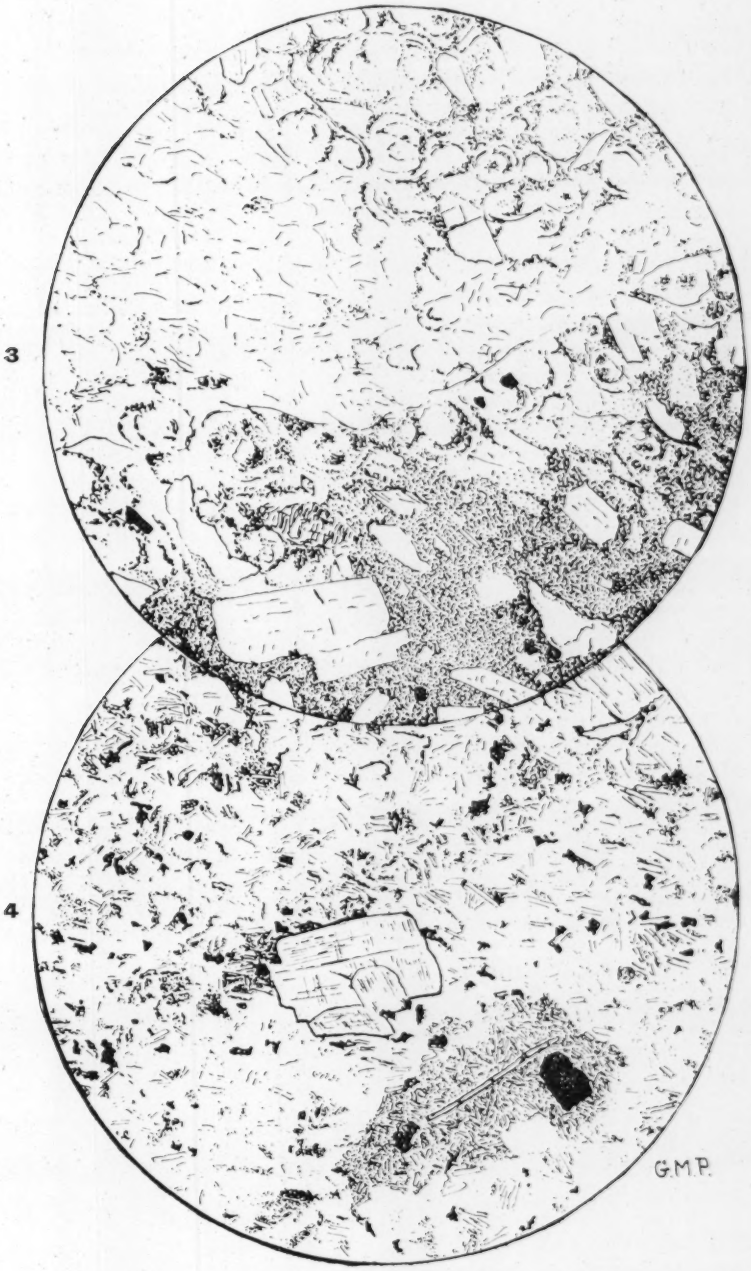


FIG. 3.—Perlitic Soda-rhyolite, 200 yards N.W. of Mynydd-du, Rosebush. × 18.
FIG. 4.—Soda-rhyolite, Craig-y-Cwm type, S.E. of old quarries, Craig-y-Cwm, N.E. of Rosebush. × 18.

chilled crust has not always been preserved. Slatey material has been washed into all the irregularities in the igneous rock, and in some cases there is a certain amount of débris of the latter in the slate in immediate contact with it.

The actual junction is not exposed along the southern side of the hill, but a specimen of the igneous rock taken from within a few yards of it shows signs of brecciation and contains patches of calcite, particularly in the felspar phenocrysts. This might be taken to indicate the albitization of a previously more calcic felspar, but I have only observed the presence of calcite in this area in those rocks, both rhyolites and trachytes, which have been brecciated or weathered, and on the whole I am inclined to regard its introduction as due to these causes, and not connected with any secondary albitization.

Two hundred yards north-west of the farm Mynydd-du ($\frac{3}{4}$ mile north of Rosebush) a grey cleaved rock, very like a tuff in appearance, crops out above the path a few feet below blue-black slates similar lithologically to those of Banc-du and the Rosebush quarries. It contains abundant phenocrysts of soda-orthoclase and albite, together with a few irregular patches of chlorite set in a groundmass which varies in texture from micro- to crypto-crystalline. This, however, was originally glassy and shows beautiful perlitic structure picked out in chlorite (Fig. 3). The patches of varying texture sometimes show a certain angularity and there are parts which are distinctly "ashy" in appearance, but on the whole this rock appears to be a fluxion-breccia rather than a tuff.

(*c*) Craig-y-cwm type: Interstratified with the slates in Craig-y-cwm (north-east side of "Prescelly Top"—marked Foel-cwm-cerwyn on the Ordnance Map), a few yards south-east of the old slate quarries, is a flow of quite a different character. This is a pale grey rock with white mottling, and of rough, almost gritty, texture. There are numerous elongated vesicles filled with quartz and limonite, and small patches of finer grain and of somewhat darker colour. These resemble the marginal portion of the rock, which is, in addition, more vesicular. The whole rock weathers a rusty brown.

Under the microscope (Fig. 4) there are scattered phenocrysts of soda-orthoclase and albite about ·04 in. in length. The groundmass has a poecilitic structure, consisting of grains of quartz usually about ·02 in. in diameter, with interstitial chlorite and granular sphene and enclosing large numbers of felspar microlites. These, which lie at all angles in the matrix, are often rather ragged and tend to occur in radiating sheaves. Their refractive index is distinctly lower than that of quartz, and the extinction angles (up to about 16°) indicate that the majority are a plagioclase of approximately the composition of albite. Some which are untwinned or simple twins, and give almost straight extinction, are a soda-orthoclase. Needles of apatite are very abundant, and there is

a certain amount of ferruginous matter—cubes of limonite after pyrites. Flow-banding is apparent in slight differences in the relative proportions of the different constituents, and to a lesser degree in the texture of the rock.

The darker patches in the rock prove to be fine-grained aggregates of felspar microlites in a matrix of chlorite, and this material, which is often somewhat "variolitic" in structure, occurs both as filling in vesicles and as irregular patches. One such patch is shown in Fig. 5, and contains, in addition to its normal constituents, several cubes of limonite after pyrites and a very large apatite. It is possible that the chloritic matrix represents originally glassy matter, as has been suggested in the case of the similar green material occurring in the rhyolites of Carn Alw.[1]

On the same line of strike a dark grey rock is exposed by a spring high up on the hillside, 500 yards east by south of Pant-maenog. Though very similar in composition to the rock in Craig-y-ewm, this is rather different in structure, the ground-mass being more granular, while the felspar microlites are more ragged and flow-banding is not developed.

(B) The Soda-Trachytes.

In the boulder-strewn valley between Cnwc and the lower slopes of "Prescelly Top" the lavas are of a distinctly "trachytic" type. As a rule, they are not so fresh as the more massive and rhyolitic varieties developed round Greenway. In the hand-specimen these rocks are usually greenish in colour, from their contained epidote and chlorite, fine-grained to flinty in texture, and often showing fluxion-banding and vesicular structures.

One of the freshest—a pale green fine-grained rock from a point 500 yards south-east of Pant-maenog—shows under the microscope (Fig. 5) phenocrysts of soda-orthoclase and albite usually about 0·7 in. in length and commonly associated together in groups, recalling "glomero-porphyritic" structure. With these is often a certain amount of epidote occasionally in pseudomorphs after pyroxene and some interstitial quartz. The ground-mass consists of little laths of felspar with interstitial chlorite and a variable quantity of epidote and granular sphene; there is also a little interstitial quartz. There are a number of round vesicles from ·05–·25 in. in diameter, which are filled with quartz.

The felspar microlites are in general about ·01 in. in length, and from five to ten times as long as broad. Some are either untwinned, or simple twins giving almost straight extinction, and are a soda-orthoclase. The majority, however, are a plagioclase, and their extinction angles, which range up to about 15°, and low index of refraction indicate a composition near to albite.

The structure of the ground-mass is "trachytic", the felspar microlites showing marked fluxional arrangement. In my own

[1] Parkinson, op. cit., p. 468.

specimens the direction of flow is not at all constant even in the area comprised in the field of view of a low-power objective, but a specimen of almost identical rock, slightly coarser in texture, in the Geological Survey Collection (No. E 5706, labelled "Prescelly Mountains, Pembrokeshire") shows a beautiful and much more regular flow-structure. A second specimen (E 5705, similarly labelled) is completely brecciated.

A rock from further up the hillside—south-east of Pant-maenog—is poorer in orthoclase. The phenocrysts, nearly all albite, make up a large proportion of the rock and grade down into the ground-mass which approaches the "orthophyric" type in structure, owing to the shorter and stouter habit of many of the felspars, some of which show the "chequer" type of twinning. Quartz occurs, but is not conspicuous except in the occasional vesicles, and the usual interstitial chlorite and granular sphene are present scattered through the ground-mass. In addition there are a number of irregular patches of calcite connected, I believe, with the evident brecciation which this particular rock has suffered, and which is well shown by the bent and broken phenocrysts—sometimes recemented by chlorite.

The rocks of Carn Afr—the prominent cliff south of the path leading from Rosebush to Craig-y-ewm, mentioned by Parkinson—are mostly far from fresh, and contain much epidote, chlorite, and secondary silica. As a rule they are highly vesicular, the vesicles being filled with chlorite often with an outer layer of small imperfect spherulites of silica. The phenocrysts are numerous, and, as usual, include both soda-orthoclase and a plagioclase near to albite; where it is not obscured by secondary products the ground-mass is trachytic and fine in grain. There is a good deal of granular sphene scattered through the body of the rock.

(c) The "Keratophyre" of Foel Trigarn.

A trachytic rock of rather different type occurs on Foel Trigarn, where it forms the lower and thicker part of the prominent crags on the south and south-west sides of the hill. Most of the hill is made up of soda-rhyolites, ashes, and breccias, which dip about 40° north (almost the same as the northern slope of the hill). The low crags below the stone cairns at the summit on the south side are formed of a sheared dolerite, another band of which is exposed lower down the hill. Immediately below the upper dolerite comes the "keratophyre". The actual junctions are obscured by heather and scree, but this appears to be a flow intercalated amongst the rhyolites and rhyolitic ashes, which latter are exposed lower down the hill, above the lower dolerite.

The rock when fresh is grey-green in colour, fine-grained, intensely hard, and breaks with a splintery fracture. It is typically non-porphyritic and non-vesicular, but weathers full of holes, brown and ferruginous, the blocks resembling lumps of slag—a form of

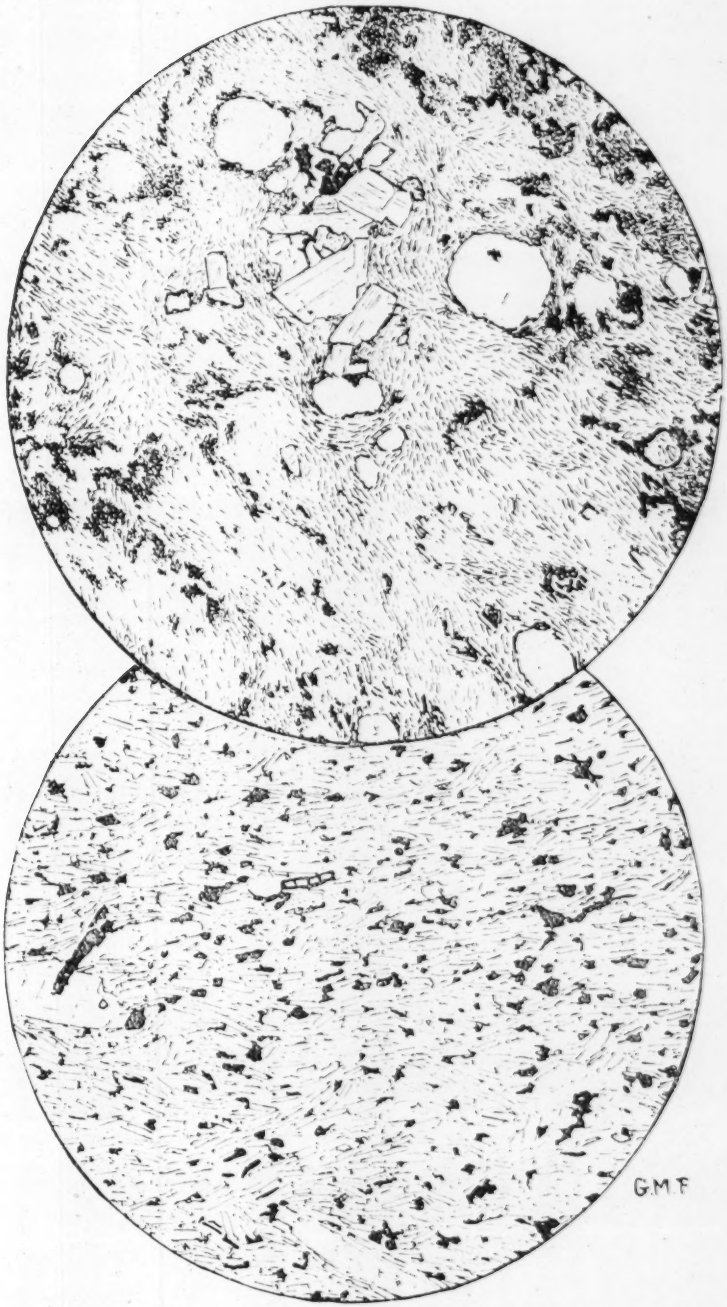


FIG. 5.—Soda-trachyte, 500 yards S. of Pant-maenog, Rosebush. × 18.
FIG. 6.—"Keratophyre" Crags, S. side of Foel Trigarn, 1 mile W. of Crymmych Arms. × 22.

weathering which also affects the rhyolites as noted by Parkinson.[1] One variety found on the scree-slopes is full of small white spots, which give it the appearance of a felspathic tuff. This, however, is a form of decomposition similar to that noted by Dr. Elsden in the "porphyrite" of Cwm-y-Graig near Mathry.[2]

In thin section (Fig. 6) these rocks are seen to consist mainly of small microlites of felspar about ·01 in. in length together with much interstitial chlorite, some granular sphene and epidote, and a little interstitial quartz. The sphene in this case has obviously arisen from the decomposition of a titaniferous iron-ore mineral, probably ilmenite, of which some irregular remnants remain. One of the peculiar features of this rock is the abundance of apatite. In many of the slices the whole rock is riddled with needles of this mineral, which must make up at least six per cent of the total bulk.

The phenocrysts are rare, and include both soda-orthoclase and albite; vesicles when they occur are filled with quartz and sometimes a little limonite.

The felspar of the microlites includes both soda-orthoclase and plagioclase. There is a considerable quantity of the former, which occurs both untwinned and in simple Carlsbad twins, and often has a rather undulose extinction under crossed nicols. The plagioclase approximates to albite in composition, having a lower refractive index than quartz, and giving extinction angles up to 15°. The structure of the rock is "trachytic" to "pilotaxitic". Superficially it resembles very closely the "lime-bostonite" or "keratophyre" of Abercastle, but is richer in orthoclase, chlorite, and iron-ores, and, in addition, is peculiar for its high content of apatite.

Specimens from the upper part of the crags show considerable brecciation, and usually contain more or less calcite.

There are two specimens (E 5717, 5719) of this type in the Geological Survey Collection, but the rock does not seem to have been previously described.

(D) Age.

The evidence for the age of all these lavas is at present very unsatisfactory, owing to the cleavage and general absence of recognizable fossils. Parkinson has noted fossils indicating a Bifidus age for the slates in the neighbourhood of Crymmych Arms,[1] and on this evidence has suggested a "Lower Llandeilo", or even Arenig age for the rhyolites of Carn Alw, which, according to that author, are slightly later than the more basic lavas found on the southern slopes of the mountains (i.e. the rocks which form the main subject of these notes).[3] Owing to the possibilities of strike-faulting, this is by no means a certainty. Parkinson also mentions that fossils are occasionally found in the Rosebush quarries, though he adds that his own search was not successful. I have like-

[1] Op. cit., p. 465. [2] Op. cit., p. 598. [3] Ibid., p. 474.

wise been unfortunate at Rosebush, but a quarry in similar slates on Banc-du yielded one specimen of a small "tuning-fork" *Didymograptus*, which I am indebted to Dr. Gertrude Elles for examining. The specimen is unfortunately rather smeared by the cleavage, but Dr. Elles is inclined to regard it as being of *D. Murchisoni* type rather than *D. bifidus*. These slates immediately overlie the rhyolites of Greenway, and it is therefore suggested that these occur either high up in the Bifidus (it must be remembered that *D. Murchisoni* var. *geminus* extends well down into this zone in South Wales) or low in the Murchisoni slates, i.e. about the horizon of the Llanrian rhyolites as originally suggested by Dr. Elsden. Until further evidence is available it would not be wise to attempt any closer correlation of these rocks.

(E) Chemical Composition.

Unfortunately there are not many analyses of the soda-rich rocks of South Wales published, and most authors have been content to quote Dr. Elsden's original analysis of the Abercastle "Keratophyre". A few analyses were made in the Survey laboratory in connexion with the Skomer series, and are given in Dr. Thomas's paper and in the Memoir on Sheet 227 (Milford). Only two of these are applicable to the present case, and are given in columns II and III below, together with Dr. Elsden's analysis as quoted by Professor Cox (IV).

Mr. Radley, who was responsible for the Skomer analyses, has very kindly made a partial determination for me of the rock from Cnwc-y-felin, west of Rosebush, and his figures are shown in column I.

	I.	II.	III.	IV.
SiO_2	72·11	79·64	58·57	55·38
TiO_2		0·50	2·17	0·90
Al_2O_3	13·89	11·44	18·60	18·34
Fe_2O_3		0·11	1·92	1·13
FeO		0·30	4·77	5·86
MgO		0·15	0·94	3·47
CaO	0·63	0·71	0·99	3·25
K_2O	2·42	0·38	3·30	0·22
Na_2O	6·36	6·40	5·52	7·12
H_2O below 110°		0·16	0·50	0·48
H_2O above 110°		0·30	2·19	2·39
CO_2		0·02	0·04	2·20
P_2O_5		0·08	0·45	tr
Other constituents	n.d.	0·08	0·25	—
	[95·41]	100·29	100·11	100·54

I. Soda-rhyolite, Cnwc-y-felin, west of Rosebush.

II. Soda-rhyolite, near the Table, Skomer, Pembrokeshire. (Anal. 345) Mem. Geol. Survey, Sheet 227 (Milford), p. 31.

III. Soda-trachyte, north cliff, Skomer, Pembrokeshire. (Anal. 347) Mem. Geol. Survey, Sheet 227 (Milford), p. 33.

IV. "Lime-bostonite", Longhouse, Abercastle, Pembrokeshire. Elsden, *Q.J.G.S.*, vol. lxi, 1906, p. 596.

Anal.	E. G. Radley	E. G. Radley	E. G. Radley	J.V. Elsden
Quartz . . .	[21·6]	39·8	6·0	4·3
Orthoclase . .	14·3	2·2	19·5	1·3
Albite . . .	53·8	54·1	46·7	60·2
Anorthite . .	[1·0]	1·3	2·2	3·5
Pyroxene . .		1·0	7·3	23·6
Other constituents	[9·3] n.d.	1·7	18·3	7·8
	[100·0]	100·2	100·0	100·7
Composition of Ab.	98·0	97·6	95·5	94·5
Plagioclase An.	2·0	2·4	4·5	5·5

In the column below each analysis I have shown the mineral composition of the rock calculated from it. That in column IV has been quoted from Professor Cox's paper. The remainder I have calculated from the analyses, and in the case of II and III will be found to differ somewhat from the figures given in the original descriptions, particularly in regard to the contents of anorthite. I believe that in these sufficient account was not taken of the accessories containing lime, such as sphene, apatite, and calcite, which collectively reduce considerably the amount of this constituent available for felspar. In the case of the rock from Cnwc-y-felin, this adjustment is not possible, except in a very general way, in the absence of figures for titanium, carbon dioxide, and phosphorus pentoxide, but the appearance of the rock under the microscope suggests that apatite is present, but certainly not in excess of one-half per cent, and sphene in greater amount, probably over one per cent. If the figures for titanium and phosphorus pentoxide are as low as those shown in column II, there is only sufficient lime left over for 1 per cent of anorthite, making a felspar of the composition Ab. 98 An. 2, which is not an unreasonable composition in view of the optical characters of the plagioclase seen in the rock. In any case, there is only sufficient alumina for the formation of 2 per cent anorthite, and this leaves out of account any chlorite present in the rock.

As regards the value given for quartz in column I, no accurate figure can, of course, be determined in the absence of a full analysis, but an approximate indication can be arrived at in the following manner. A consideration of the other analyses shows that the proportion of silica taken up by constituents other than alumina, lime, and alkalies, lies between 60 and 70 per cent of the total of such constituents. If we take the higher figure of 70 per cent, the 4·6 per cent of constituents "not determined" will account for 3·2 per cent of silica. The felspars (using the "corrected" figure for anorthite) account for a further 47·3 per cent of silica, making 50·5 per cent in all, and leaving 21·6 per cent present as free quartz.

The foregoing descriptions and analyses show clearly that the affinities of these rocks lie with the soda-rhyolites and trachytes

on the one hand, and the "keratophyres" on the other—using the term "keratophyre" in the same sense in which it has been employed in connexion with the Skomer Series.

In conclusion, I desire to thank all those who have assisted me in the course of the work, in particular Dr. H. H. Thomas, to whom I am indebted for a vast amount of kindness and encouragement, and Mr. J. R. P. Penn, of Poyston, Haverfordwest, for his company in the field.

Notes on the Brandesburton Kame, Yorkshire.

By James Phemister, M.A., B.Sc.

(PLATE XV.)

In the Geological Magazine for December, 1921, Professor J. W. Gregory has referred to the Brandesburton Kame in a paper dealing with English Kames and Eskers. He points out that further information is required to determine its true nature. The following paper is the result of observations which were made on a visit to Brandesburton in August, 1921. The ridge appears to be a true kame of fluvioglacial character.

The ridge in question has a length of between 3 and 4 miles, and can be traced in Sheets 196 N.E. and 179 S.E. Ordnance Survey 6 in. map. It begins at Gildholm Hill, fully half a mile south of Brandesburton Church, passes 10 degrees north of west through Coneygarth Hill, crosses the Leven–Brandesburton road at Starcarr Gate, takes a north-west direction along Starcarr Hill, turns north at Burshill, and ends just south-east of Hempholme. On the 1 in. map its course is easily traced, as it coincides with the road from Starcarr Gate to Hempholme, the road having probably been made along it owing to the wet nature of the "carr" country through which it passes. "Carr" indicates boggy ground. Trees or tree-stumps mark a considerable part of its course in the field. The trees have been felled, and the kame greatly lowered by former excavations immediately west of Starcarr Gate. The kame is leased out to contractors, and work is in full progress at this part.

The notes in this paper refer only to Coneygarth Hill and the pit immediately west of Starcarr Gate.

Coneygarth Hill is a flat-topped, parallel-sided mound, about 6 feet high and 60 yards broad. It contains several depressions which are probably former pits, and at one point rises to a conical hillock about 30 feet above the rest of the ridge. South of the main ridge two small mounds, the larger 100 yards long, run parallel to it. "George" pennies, 232 years old, have been found by workmen in the excavations, indicating that the hill was probably dug for gravel in the eighteenth century.

Material of Coneygarth Hill.

Small gravel is seen at the mouths of rabbit-burrows on the flat top; towards the eastern end the ejected material is sandier. A pit on the west side of the hillock shows the following section :—

Small gravel, Sand with shell fragments, Gravel	15 ft.
Coarse sand with shell fragments and coaly layers	5 ft.
Coarse gravel, mostly subangular	2½ ft.
Small gravel	½ ft.
Loam, hidden by talus	possibly 3 ft.
Red clay	3 in.
Brown clay	4 in.
False bedded sand with shelly and coaly layers	2 ft.
Coarse gravel with worn facetted stones of large size (8 in.)	4 ft.
Fine gravel	2½ ft.
Small gravel	½ ft.
Very fine gravel	2 ft.

The thicknesses are approximate.

The section does not persist across the ridge, for the 4 feet of coarse gravel gives place on the right to sand of a uniformly fine character without shell fragments. Also the seam of clay dies out on the right. But the section towards the right edge is obscured by debris.

Analysis of the gravel (pebbles of 2 in. diameter being selected) shows that the great majority are subangular, about 20 per cent rounded and 10 per cent angular. No pebbles bearing striæ were found. The small pebbles (1 in. and under) are generally rounded and pebbles of stratified rock are worn to discs. The pebbles include :—

Limestones, crinoidal, magnesian, cementstone.
Sandstone, white, purple, yellow, and compact white Jurassic.
Flint, black, white, and waxy-looking.
Basalts, compact to porphyritic, fresh to rotten.
Andesites, chocolate coloured.
Quartzites, schists, fine green grit.
Chalk in very small quantity.
Coal and coaly shale.
Fossils including *Gryphæa*, ammonite, belemnite.

I am indebted to Mr. G. W. Tyrrell, F.G.S., of Glasgow University, for identifying the following among the igneous rocks: Quartz-porphyries, felstone, felspar-porphyry, all probably from Cheviot Old Red Sandstone igneous region, pink granites probably not Scottish, hornblende-schist, hornblendite, augite-porphyry, lamprophyre, aplite, a syenitic rock, and several red and dark-green rhomb-porphyries. There is also a basalt which strongly resembles an essexite-basalt from Grorud, Norway, but may be an uncommon variety of Scottish Carboniferous basalt. According to the workmen coal is found all through the gravel, and as the section shows also forms layers. Judging from its poor quality it has probably been derived from Jurassic coal seams. Similar layers of coaly material are common in the kames of Carstairs.

Stratification and Bedding.

The section shown by the Coneygarth Hill pit is transverse to the ridge and the looseness of the material causes angles to crumble

away, so that there is little opportunity of observing the dip of the beds. The section, however, gives clear evidence of deposition by water. The coarse gravel has a suggestion of stratification, but all the fine gravels show distinct bedding planes which are horizontal. The sands lie horizontally between the gravels and some show current bedding, particularly the sand immediately beneath the clay. The clay and coaly layers are both horizontal. Tracing the stratification towards the margin, the clay is seen to thin out and droop. Also the beds did not persist, e.g. the 4 feet of coarse gravel passed into a very fine sand without shell fragments and with no false bedding, but it was not possible to observe the junction nor to trace any bed far, as the pit is in the centre of the hillock and the edges are smothered in debris.

Though this pit gives no indication of dip, a trench cut longitudinally in the ridge between Coneygarth Hill and Starcarr Gate shows a very small dip to the west along the ridge and a very gentle inclination towards the margin. This trench shows no sand, but only thin alternations of coarse and fine gravel whose composition is the same as that in Coneygarth Hill.

There is no seasonal banding in the Coneygarth Hill pit, and that it does not occur in the ridge is shown by the absence of alternations of broad and narrow patches along its course, for it remains parallel-sided throughout. The existence of Coneygarth Hill is not due to the presence of any particularly resistant band of gravel, since it is composed of alternations of hard and soft horizontal beds which are scarcely cemented at all.

Section in Pit west of Starcarr Gate.

This pit gives both transverse and longitudinal sections. The longitudinal section shows a small dip to the west along the ridge. The sequence is :—

Small gravel Sand Gravel Fine gravel Gravel	5 ft.
Fine gravel and coarse sand interbedded	4 ft.
Sand	2 ft.
Gravel below.	

False bedding is present, but is not very pronounced. The transverse section shows a fault whose downthrow is towards the margin of the ridge, and gives the above section. The section on the upthrow side is :—

Gravel
Coaly layer
Orange-coloured sand
Clay
Sand

The clay dips towards and is streaked out against the fault. There is no distortion of the beds, but a gentle waviness has been introduced such as might be produced by a slip of material whilst still wet and plastic. Possibly the thinning out and droop of the clay and the replacement of one bed by another in the Coneygarth Hill pit is due to a similar cause, the fault itself being hidden in the debris.

The gravel in this pit has the same composition as that of Coneygarth Hill and a rhomb-porphyry was found here also.

Mammoth bones have been recorded from the Brandesburton gravels,[1] but the writer found no bones, and no shells except the waterworn fragments in the shell sand. Among the pebbles were found an ammonite, a *Gryphæa*, and a belemnite, all well waterworn.

Summary.

1. The direction of the ridge is roughly parallel to the line of the moraine in Holderness as sketched by Carvill Lewis.
2. The material of the gravels is ice-collected, but is well waterworn though not rounded. The bulk of the pebbles are of north-eastern England and Yorkshire origin, and a small proportion of Scandinavian rocks is present.
3. The stratification is horizontal and current bedding is frequent.
4. There is no seasonal banding nor any alternations of broad and narrow parts along the length of the ridge.

Conclusion.

From the evidence which I have been able to collect, the ridge is therefore probably a kame of fluvioglacial character. That it is surrounded by "carr" land on *both* sides points to its having been formed in a sheet of water. The parallel sides are probably due to slipping along planes parallel to the length, and this would also explain the existence of the small parallel mounds previously mentioned. The talus produced by the slipping would soon be spread evenly over the floor.

The composition of the gravels indicates that the streams which deposited the kame were fed by Cheviot ice which had probably overridden deposits previously formed by the Scandinavian ice.

In conclusion I must express my great indebtedness to Professor J. W. Gregory, F.R.S., who pointed out the work and was always ready with helpful suggestions.

EXPLANATION OF PLATE XV.

Fig. 1.—The low ridge of the kame is dimly seen in the foreground, runs through Coneygarth Hill, and sweeps round to the right, causing the rise on which the Starcarr Gate houses stand.

Fig. 2.—The section is across the kame. Note the horizontal bedding, and the gravel at the base and top. The sand is seen on the right centre, and the thin clay band lies at the foot of the talus above the centre line of the photograph.

[1] John Phillips, *Illustrations of Yorkshire Geology*, pt. i, p. 22, 1835.

FIG. 1.—CONEYGARTH HILL AND STARCARR GATE.

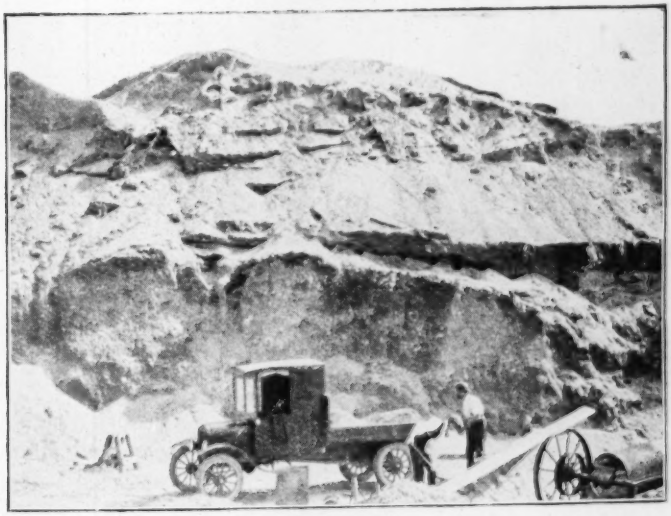


FIG. 2.—CONEYGARTH HILL GRAVEL PIT (SECTION).

[To face p. 326.

REVIEWS.

NOUVEAU TRAITE DES EAUX SOUTERRAINES. By E. A. MARTEL. Large octavo, 840 pp., with 384 figures. Published by Octave Doin, Paris. Price 50 francs.

ALTHOUGH boring to effect the release of subterranean water under pressure was accomplished in Egypt and elsewhere in early times, even before the Carthusian monks of Lillers opened the first well in the province of Artois in 1126, the people of France, wherever they settle, seem to be as much impelled by an inevitable tendency to put down an artesian well as the British soldier is to lay out a football ground wherever his army halts for more than a week. The application of science to the search for underground water seems to be with the French a distinctive national trait, an irresistible instinct. One cannot read M. Martel's fascinating work without becoming infected with the spirit which runs through every page of the text and is reinforced by numerous well-reproduced illustrations. Throughout there is the personal touch of the *dévoué*, who is—if one may be permitted the metaphor—simply saturated with his subject, and wishes his reader to share with him the joy that he has had during the thirty-eight years which he has devoted to the varied aspects of water underground. M. Martel speaks of his *Nouveau Traité* as a mere appendix to Daubrée's classical *Eaux Souterraines*. It is, in effect, the product of restating in systematic form the results embodied in fifteen special works and some 500 shorter papers on various branches of the question which have arisen from the author's researches in many parts of Europe and America since 1883. Although abundant references to previous literature are methodically arranged and systematically summarized with a due sense of relativity, the mechanical effort of the laborious compiler is everywhere dominated and enlivened by the spirit of the enthusiast.

The author passes lightly over those aspects of the subject that are widely known and generally accepted, such as the meteoric cycle, the general geological activity of water, the theory of artesian springs, the chemical and bacteriological qualities of potable water, the processes of search for and *captage* ("exploitation" is perhaps the most convenient English word) of water, and the processes for its purification for domestic and industrial uses. On the other hand, he plunges more deeply into those subjects that have given rise to theoretical controversy, in which new ideas have been developed and old prejudices have been shaken by recent researches. A full discussion is accordingly given of the importance of rock-joints, fissures, and faults in determining the direction of underground channels, the common laxity of ideas expressed by the term "water table", the distinction between porosity and permeability, the relations of infiltration to evaporation and run-off, the circulation of subterranean water and its influence on the production of mineral

veins, the origin of thermal springs, the mechanism of geysers, the hygiene of potable water, the values of different colouring matters in tracing currents below ground, and the claims of the water diviner. To summarize the author's observations is as difficult as abridging a dictionary, and in the short space allotted to this notice one can exhibit a few stray specimens but hardly representative samples.

The earlier chapters are dominated by a desire to correct the "errors" of German, Austrian, and Swiss "professors"—Rutimeyer, Heim, Tietze, Penck, Grund—"who, without having gone sufficiently to study personally the actual phenomena underground . . . have denied the influence of fractures in the formation of valleys." M. Martel "holds very strongly, not from the teaching of professors, but after having undertaken in complete independence of judgment, thirty-eight years' observations on subterranean and torrential waters, that below ground, as on the surface, fractures play a capital rôle in the formation of caverns as well as in the formation of a great number of valleys." He backs his conclusions by a wealth of illustrations drawn from widely separated areas, but he does not make them more convincing by ascribing other views to the influence of "German pedagogy which explains the facts by the ideas, not the ideas by the facts" (pp. 66 and 67), or by asserting that any conflicting theory can be held only through ignorance or prejudice (p. 147). It is, of course, possible that a dominant political system, artificially raised to the level of a national religion, may influence the tone of a country's scientific thought, but in every community there still remain individuals who desire to arrive at the truth and are not wholly inhibited by nationalism. To quote a number of Allied writers on other quite different subjects to show that our late enemies have been dominated by "puff, bluff, and pedantry" does not suggest to the neutral reader that the author trusts sufficiently to the significance of the facts which he quotes with laborious care and meticulous precision.

In other matters, too, even the natural vanity of the reader might be relied on to respond if the author only allowed him to discover for himself, from the abundance of dated quotations, the marked change which has come over the science of speleology during the past thirty-eight years; the specific references to the significance of the year 1883 (e.g. on pp. 5, 147, 236, and 756) seem to be an unnecessary simplification of a simple inference. Nor do the dicta of a recognized master acquire additional weight by adventitious forms of reinforcement, such as the use of italics and one, two, or even three marks of exclamation. The author could have rested more placidly on the circumstance that the penetration of truth, like many other natural phenomena, is governed by the law of uniformity. These by-products of enthusiasm, however, add on the whole more to the human interest of the book than they detract from its value as a judicial pronouncement.

M. Martel attempts to lay down definitions that will help to introduce uniformity in the common usage of several terms which, in referring especially to those associated with porosity, he characterizes as a veritable confusion of tongues descended straight from the tower of Babel. He thinks that one ought to regard as *porous* those rocks which are penetrable by water but which, unlike those that are *permeable*, are not entirely traversed by it; they retain in their interstices (or pores) a proportion more or less great of the water which succeeds in percolating only under pressure. Porosity is thus a state intermediate between permeability and impermeability, in consequence of a conflict between capillarity and gravity. M. Martel classifies rocks according to their behaviour to water, as (1) impermeable, (2) porous and impermeable, (3) porous and permeable, (4) permeable without porosity. This restriction of the term porosity is at variance with the common usage of oil geologists, but, without discussing at this stage the merits of alternative terms, everyone will agree that an advantageous uniformity will be gained by adopting M. Martel's definitions.

Similarly, the author attempts to correct popular usage by defining the terms attached to springs. He uses as a general term *emergence* to cover (*a*) a *spring* of naturally filtered water which issues from permeable detrital rocks, and (*b*) a *resurgence*, or the reappearance of an underground river, such as one meets in a limestone country. The term *fountain* is limited to an artificially developed emergence.

Although the subjects are well classified, with numerous subdivisions distinctly indicated by expressive headings, the book loses seriously in value as a work of reference by the absence of alphabetical indices of authors, localities, technical terms (especially those of local application) and subjects. This shortcoming could be repaired by an English translation, which would serve to arouse interest in a subject that has received far too little attention by English naturalists, chemists, medical men, and engineers.

T. H. Holland.

A Textbook of Mineralogy. By E. S. Dana. Third edition, revised and enlarged, by W. E. Ford. pp. ix + 720, with 1,050 figures. New York: Wiley. London: Chapman and Hall, 1922. Price 25*s.* net.

THE present writer learnt his descriptive mineralogy almost entirely from the "little Dana", with occasional excursions in the direction of the "big Dana" for minute detail in special cases. Being a person of conservative tendencies he has continued to use Dana, in spite of the great number of admirable modern American and German books of reference now on the market. With much pleasure, therefore, he welcomes the appearance of a third and up-to-date edition of the *Textbook*, combining all the old familiar features with modernization of those parts of the subject that

have undergone important changes and developments since the appearance of the second edition in 1898. No doubt it would be possible to pick out individual examples of omissions of recent work, but this is not the real object of this review, which is to give a general impression of the book as a whole, and in this case the general impression is excellent. The sections on physical properties in general have been revised, and the part dealing with optics has been largely rewritten and greatly improved. Concerning crystallography, the most important addition is the introduction of the methods employed in the use of the stereographic and gnonomic projections, and Appendix A, on crystal-drawing, has been largely rewritten. Appendix B has been greatly enlarged by the addition of an elaborate table of minerals arranged according to chemical composition, which will be useful to those desiring to ascertain all possible sources of some given element. For these days the book is decidedly cheap.

Special Reports on the Mineral Resources of Great Britain. Vol. XX, Lead and Zinc. The Mining District of North Cardiganshire and West Montgomeryshire. By O. T. Jones, M.A., D.Sc., Mem. Geol. Survey. pp. vi + 205, with xxvii plates, 4 text-figures, and a coloured map. 1922. Price 7*s.* net.

THE publication of this report has been anticipated with much interest by mining geologists. Professor Jones was admirably qualified for the task of writing it by his intimate knowledge of the structure and stratigraphy of this region, which he has made peculiarly his own, and the Geological Survey is to be congratulated on having secured his services for the purpose. He brings out with the utmost clearness the close connexion between the folding and faulting of the area and the distribution of the ore-deposits, which have been in the past of great importance and still contain possibilities of extensive development under more favourable economic conditions. The mineralized veins are entirely confined to the Bala and Llandovery strata, but these alone are estimated to be 10,000 feet thick, and practically all the payable lodes are faults or shatter-belts striking approximately east and west. The relationship between folding, faulting, and ore-deposition is close, and Professor Jones is inclined to attribute the mineralization to the later phases of the Caledonian earth-movements, although there is no positive proof. Some of the later faults which displace the lodes may be of Hercynian origin.

This report is an excellent addition to this most valuable series. Without wishing in any way to be ungracious, we venture to raise a protest against the intolerable and cumbersome length of the official titles of many of these reports, which are a perfect nightmare to bibliographers and to authors wishing to quote them in footnotes. It will eventually be necessary to devise some shorter form of reference than the strictly orthodox designation, as set out at the

head of this review, and this is by no means an isolated example: some are even worse than this.

Transactions of the Hull Geological Society. Vol. VI, Part IV, for the years 1910–1921. Edited by T. Sheppard, M.Sc., F.G.S.

Transactions of the Leeds Geological Association. Part XVIII, 1913–1920.

After an inevitable temporary eclipse due to war conditions, our local geological societies are now making praiseworthy efforts to publish the results of much useful work done during the last few years. The two parts of *Transactions* quoted above contain numerous interesting notes on a wide range of subjects. The first-named contains papers by Mr. T. Sheppard, on Early Humber Geography, a subject to which he has contributed much valuable knowledge by his investigations; by Mr. W. H. Crofts and Mr. F. L. Pawley on the geology of a new dock at Hull; by Mr. Bisat on new sections, well-sinkings and borings in Cretaceous and Jurassic strata near North Ferriby; by Mr. J. W. Stather on a new section in Glacial deposits and Oolites near South Cave; by Mr. Sheppard on the water supply of Hull, and notes on excursions, illustrated by numerous plates and text-figures, all apparently un-numbered.

The publication from Leeds also contains much of interest, mainly in the form of very short notes and abstracts, including Creep, by Mr. H. Preston, an account of rock movements caused by engineering work; A Borehole at Meanwood, by Mr. A. Gilligan; Peat Problems, by Miss E. D. Whitaker, dealing mainly with composition and ash-content of different peats; Notes on some sections in Elland Road, Leeds, by Messrs. J. H. Everett and G. F. Pickering. These are well illustrated by plates and figures. There are also extracts from annual reports and notes of excursions.

Both societies are to be congratulated on the resumption of their publishing activities.

The Mutue Fides-Stavoren Tinfields. By Percy A. Wagner, Ing.D., B.Sc., etc. Union of South Africa Geological Survey Memoir No. 16. pp. 192, 31 plates, 27 text-figures. 1920. 7*s.* 6*d.*

After discussing the general conditions and physical features of the district, the writer deals at some length with the petrology of the acid members of the Bushveld complex as developed in these tinfields. These consist of granite, granophyric granite, and granophyre in a stratiform laccolith with a xenolithic zone where the laccolith came into contact with the Waterberg quartzites. No evidence of magmatic assimilation of these quartzites has been obtained. The pegmatites associated with these intrusions are divided into intrusive and segregation pegmatites, the former

showing all variations from pure quartz to pure felspar. The quartz-rich pegmatites predominate in the granite and the felspar-rich in the granophyre. The minerals of the rare earths are entirely absent from the pegmatites of this portion of the Bushveld complex.

There is a short note on the local occurrences of norite and pyroxenite, and the lithology of the various sediments of the Waterberg system in the area is dealt with in detail. A short account is given of the volcanic series, which appears originally to have consisted chiefly of hyalopilitic andesites: these have suffered intense secondary silicification, a phenomenon not exhibited by the tuffs and sedimentary rocks with which the lavas are interbedded. Quartzites and shales of the Pretoria series are overthrust on to the Waterberg system in the southern part of the district. Quartz veins, traversing the central portion of the area, show many structures and variations—one, 150 yards wide, has induced intense sericitization in the adjoining granite and granophyre up to 200 yards on each side.

Turning to economic geology, the chief mineral deposits of the area are cassiterite, scheelite, copper ore, and white arsenic. The ore deposits are very erratic and consequently difficult and expensive to work. An account of the fifty minerals identified is given, and an analysis is shown of the "raven-mica" which, as at St. Just and Altenberg, accompanies the cassiterite (in the granophyre). Cassiterite is the only recoverable mineral in the granite, and was apparently formed before the main period of sericitization. The normal granophyre never forms the country rock for mineral deposits, all deposits being in syenitic modifications of, or pegmatitic bodies in, the granophyre. The individual deposits in these rocks are described in detail, as are those in the Waterberg quartzite. All the deposits are evidently genetically connected with the Bushveld granite, and the author distinguishes five phases of deposition. With regard to the vehicle of deposition, no satisfactory conclusion is reached, though it is of interest that no tourmaline has been found except in one pipe.

The memoir finishes with chapters on the Mining and Ore Treatment, and the Future of the Fields.

J. E. A. W.

Geology and Ore Deposits of Ainsworth Mining Camp, British Columbia. By S. J. Schofield. Memoir 117, Geological Survey of Canada. pp. iv + 73, 12 maps and diagrams, 3 plates, 6 figures. 1920.

THE Ainsworth mining district lies in the Selkirk Mountains, some 400 miles east of Vancouver, just north of the International Boundary.

The sediments of the area are divided into two main groups—the unfossiliferous Ainsworth series, which is pre-Carboniferous, and the Slocan series, which is probably Pennsylvanian. The former consists

mainly of limestones and schists, invaded at various horizons by narrow dykes of gneissic granite. The Slocan series is formed of limestones and argillites. The next deposits are Quaternary.

The mineralization was induced by the great Nelson (West Kootenay) granite batholith—a quartz-monzonite of Jurassic age, associated with it being camptonite dykes, later than the consolidation of the granite, but previous to the mineral deposition. The important economic deposits are silver-lead ores, which appear as true fissure veins and metasomatic replacements in limestones. The ores consist of argentiferous galena (20 oz. silver to the ton) and zinc-blende in a gangue of calcite, siderite, quartz, and fluorite. The replacements and veins are evidently contemporaneous. Detailed descriptions of the mines are given, the general prospects of the area being good, the value of the production in 1918 being $662,388.

In an interesting final chapter the author ascribes the Purcell trench, in which Ainsworth is situated, to river-carving in Tertiary and Quaternary times in a peneplain, and not to faulting, as suggested by Daly.

J. E. A. W.

Contributions to the Geology and Palæontology of the West Indies: Fossil Echini of the West Indies. By Robert Tracy Jackson. Stratigraphic Significance of the Species of West Indian Fossil Echini. By Thomas Wayland Vaughan. iv+122 pp., 18 plates, 6 text-figures. Carnegie Institution of Washington. Publication No. 306, 15th February, 1922.

Of the eighty-nine species of fossil Echinoids known from the West Indies only eight are found in the Cretaceous, and they belong to the genera *Codiopsis*, *Salenia*, *Phymosoma*, *Conulus*, *Lanieria*, *Discoidea*, *Cardiaster*, and *Hemiaster*. Examples of fifty-seven of the species (of which sixteen are new) have been studied by Dr. Jackson, and of these figures and careful descriptions are given. In order to give completeness to the work references and localities of the species of which specimens were not examined are included.

With regard to the geographical relationship of the Tertiary species Dr. Jackson says that the genera *Anomalacanthus*, *Laganum*, *Peronella*, *Brissus*, *Eupatagus*, and *Breynia* found fossil in the West Indies are at the present day essentially Indo-Pacific types; and three species of *Cidaris* find their nearest living allies in Australian or Japanese seas. *Clypeaster oxybaphon* n.sp. is related to an Indo-Pacific form. The species of *Echinolampas*, of which seven are known from the Eocene and Oligocene, are more like the Recent Indo-Pacific forms than like the living West Indian species.

Dr. Jackson's memoir is followed by a paper on the stratigraphical significance of the species by Dr. T. W. Vaughan.

Post-Glacial Warping in Newfoundland and Nova Scotia. By R. A. Daly. Amer. Journ. Sci., 5th Series, vol. i, 1921, pp. 381–391.

In continuation of his studies on crust-warping as a result of the removal of ice-load, Professor Daly in 1920 revisited Newfoundland and Nova Scotia with a view to correcting and amplifying previous observations. He concluded that the amount of uplift at St. John's had been overestimated. It was found that a zero isobase runs through the south of Newfoundland, while at the northern extremity the uplift amounts to 450 feet, while in Labrador on the north shore of the Strait of Belle Isle there is a maximum of 500 feet; further north the uplift appears to diminish again, as at Cape St. Charles it is only about 360 feet. The average gradient is about 2·5 feet to the mile. De Geer formerly placed the zero isobase too far south, but his general conclusions were justified. Nova Scotia has not been uplifted since the Glacial period; on the contrary, everywhere, except in the extreme north-west, there is evidence of drowning. East of the Gulf of St. Lawrence the isobases tend to run concentrically around the Labrador centre of glaciation, but it is possible that a secondary influence of the independent Newfoundland ice-cap may eventually be established. The later part of the paper contains a general discussion of the evidence as to the date of the movement. The rise of the coast is obviously very recent, judging from the absence of wide wave-cut benches in soft drift, and possibly occurred during the last three or four thousand years.

The Mineral Industry of the British Empire and Foreign Countries. Imperial Mineral Resources Bureau. Gold, pp. 366, 6*s*. Platinum and Allied Metals, pp. 84, 2*s*. Copper, pp. 203, 4*s*. Tin, pp. 98, 3*s*. Lead, pp. 95, 3*s*. Mica, pp. 32, 9*d*. Sulphur and Iron-Pyrites, pp. 67, 1*s*. 6*d*. All published 1922.

We have here another batch of these extremely useful bulletins, giving in each case a synopsis of output and markets of economic products during the period 1913–19. Besides the necessary statistics, however, each also contains a good deal of useful information as to the geology and mineralogy of the principal deposits, such as cannot fail to be of great value on the scientific side, and a very valuable feature is the extensive bibliography of each product. In the case of copper this runs to no less than 30 pages, and in gold to 20 pages. These bulletins can be obtained from H.M. Stationery Office, Imperial House, Kingsway, W.C. 2, or 28 Abingdon Street, S.W. 1, or from the local offices in Manchester, Cardiff, Edinburgh, and Dublin.

EXPLANATORY GUIDE TO THE RELIEF MAP OF THE GEOLOGY OF THE BRISTOL DISTRICT. By Professor S. H. REYNOLDS, M.A., Sc.D. Bristol Museum and Art Gallery, Publication 19. pp. 19, 1921. Price 3*d*.

WE are glad to learn that the Bristol Museum has now acquired a model, on the scale of 3 inches to one mile, showing the topography and geology of the district. The Bristol area has long been known as one of exceptional interest, and this model, together with the lucid account of the physical and geological history of the region contained in this pamphlet, cannot fail to be of great value to geologists, whether possessing local knowledge or not. The Curator of the Museum, Mr. H. Bolton, is to be congratulated on the enterprise that led to this happy undertaking. May this example encourage all other local museums to do likewise.

CORRESPONDENCE.

DAVIESIELLA LLANGOLLENSIS (DAV.) IN DERBYSHIRE.

SIR,—I have recently had the good fortune to find typical examples of *Daviesiella llangollensis*, near Topley Pike, between Millers Dale and Buxton, almost in the middle of the typical east and west section described by Dr. Sibly in 1908 (*Q.J.G.S.*, vol. lxiv). This occurrence and the associated fauna, together with the lithology of the beds, suggest that the upper part of Horizon 8 (C_2–S_1) is present here, and in a forthcoming paper I am dealing with this important fact. In the same paper I am also adducing evidence in favour of a much earlier age for the famous "Brachiopod Beds" of the Midland area, and suggesting the possibility of a marked hiatus between the massive limestone including the "Brachiopod Beds" and the overlying shale-series, in certain parts.

J. WILFRID JACKSON.

MANCHESTER MUSEUM.
20th May, 1922.

DINOCOCHLEA.

SIR,—It seems almost ungracious to point out an omission in Mr. B. B. Woodward's admirable paper on the molluscan monster from Hastings; but would he be kind enough to give the derivation of his new generic name? There are two alternatives consistent with correct etymology and the nature of the fossil, and experience has taught me how unsafe it is to assume that one of them is more likely than the other to have been in an author's mind.

To pass from the particular to the general: A museum curator soon learns how curious the public is to know the meaning of names, ten far from clear even (or, sometimes, especially) to scholar. The systematist also recognizes that much